Rhythm and Blues: The Effect of Music on Movement Patterns and Anxiety

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Abstract

Previous research has described some interactive relationships among music, movement, and anxiety. While a few creative art therapy studies have supported the idea of positive effects on health, most of these results have not been systematically investigated or replicated. The purpose of this project was to explore methods of quantifying the effects of music on movement patterns as well as their interactive effects on levels of state anxiety. Using a 9-camera VICON motion capture system, kinematic measures were obtained when nine healthy young adult non-dancers completed a 30-second whole body movement task with and without music playing. These two conditions (music/silent) were tested on different days and the order was balanced across participants. From these data, heel strike time (during walking) and wrist pause times (during arm movements) were identified. The relative timing of these movement events was then studied and compared to the timing of the beats in the music condition. Physiological measurements (pulse rate and blood oxygenation) and a state-trait anxiety assessment were administered before and after practicing and performing the movement task during each session. All participants also completed a questionnaire after each session, describing their thoughts about their performance and their attention. Analysis of kinematic data focused on the following variables: variability of heel strike timing during stepping, variability of wrist inter-movement intervals, and synchronization of each movement event with the music beat (during the music condition). Interactions between these kinematic measures and the measures of anxiety across testing conditions were also examined. One subgroup of participants exhibited marked reduction in anxiety following the movement task, others did not. This subgroup

was further analyzed to identify potential contributing factors. In addition, there did appear to be an interactive effect of the order in which the music conditions were tested, because the reductions in anxiety were usually during the participants' second testing session, regardless of testing condition. This practice effect also was found when the movement kinematics were examined for synchronization with the beat of the music. The effect of music was observed in addition to this practice effect, as some participants who had a larger anxiety reduction in the music condition than the silent condition showed lower movement variability in the music condition than the silent condition, regardless of testing order. These findings should inform future research examining interactions between movement and music as they affect participant anxiety.

Introduction

Anxiety is a mental condition that affects all populations, including those without a neurological mental illness (Kendrick & Pilling, 2012). It involves having an overwhelming feeling of worry, nervousness, or unease, typically about an event or something with an uncertain outcome. Usual symptoms include chest pain, flushing skin, a racing heart, and difficulty breathing. The word anxiety is sometimes used interchangeably with that of stress in everyday language. Although anxiety may be accompanied by stress, or even caused by stress, these two conditions are distinct. The fundamental reason stress is not the same as anxiety is that it is a state that may have physiological, cognitive, or emotional causes. As such, a person may be stressed – as may happen during hard exercise - but not feel anxious. Anxiety can be caused by stress from things such as work, school, a relationship, financial struggles, medication side effect, or emotional trauma. Physiological responses in the Autonomic Nervous System can be caused by changes in anxiety.

Like anxiety, listening to music can also lead to autonomic physiological changes. Although people vary on their preference and rhythmic interpretation of music, movement can be combined with music to capture kinematic characteristics such as walking speed (Franek, Noorden, & Rean, 2014). These studies have served as therapy tools for clinical populations with gross motor deficits as well as provide insight into how people move rhythmically. Creative art therapy is a form of psychotherapy that uses art, music, drama, dance/movement, or poetry/creative writing to help clients. Kinesiology research looks at the areas of health education, exercise physiology, motor behavior and neuroscience, sport education and sport management. The knowledge and aspects of music and dance/movement from creative art therapy along with motor behavior and neuroscience from kinesiology research can be combined together to provide a detailed explanation of the phenomenon of whole body movement related to anxiety and music.

Anxiety can be affected by medication, exercise, meditation, and music

Taking medication, exercising, meditating, and listening to music are ways known to help reduce anxiety (ADTA). Moderate-intensity aerobic exercise can significantly increase positive well-being and vigor scores on mood assessments for individuals being treated for major depressive disorder as well as reduce psychological distress, depression, confusion, fatigue, tension, and anger (Bartholomew, Morrison, & Ciccolo, 2005). For example, Hayakawa et al. found that aerobic dance music was associated with significantly more vigor and less confusion than when not listening to music (Hayakawa, 2000). Exercise also has the added benefits of increasing self-esteem, improving mood, improving executive function, and possibly improving cognitive function for people with dementia (Behrman & Ebmeier, 2014) along with the benefits that physical exercise brings to health.

Additionally, breathing techniques from meditation practices such as yoga are known to help alleviate anxiety, depression, and everyday stress (Brown & Gerbarg, 2005). Subjective anxiety can be reduced by listening to relaxing music (Knight & Rickard, 2001). Since tolerability of pharmacological agents decrease with age, finding an alternative route such as exercise programs incorporating meditation and music to help with confronting and coping with anxiety instead of medication may appeal to a different group of people as well as yield better results (Behrman & Ebmeier, 2014).

The autonomic nervous system and Its Involvement with anxiety

The autonomic nervous system (ANS) connects the central nervous system (CNS; brain and spinal cord) with the major peripheral organs and organ systems. The ANS controls internal body processes such as blood pressure, heart and breathing rates, body temperature, digestion, and metabolism (Purves, et al., 2012).

Research on biological effects on anxiety-related physiological changes include blood pressure, EEG, heart rate, and salivary immunoglobulin A concentrations (IgA). The ANS is split into the sympathetic and parasympathetic divisions. The sympathetic division prepares the body for stressful or emergency situations and causes physiological changes such as dilated pupils and increased heart rate. The parasympathetic nervous system (PNS) division controls body processes during ordinary situations and causes physiological changes such as decreasing the force and rate of heart contractions. Under resting conditions, the PNS dominates cardiovascular physiology (e.g., Levy, 1997). Anxiety also affects the physiological measures of pulse rate and oxygen saturation. Increased anxiety activates the sympathetic nervous system, as manifested by a heightened heart rate (HR), blood pressure, respiratory rate (RR) and neuro-hormonal responses (Han, et al., 2010).

Physiological effects from listening to music

Because of its large spectrum in genres, music can have a wide variety of physiological effects, particularly when people are performing some kind of exercise activity. In fact, music and exercise can both affect autonomic nervous system activity.

In Urakawa 2005, researchers measured the heart rate variability of healthy young participants before and after completing an exercise program while they were listening to preferred music or no music during the pre- and post- exercise rest periods. This study found that after completing the exercise program, when the sympathetic nerve activity was high, the activated physical response synchronized with the music playing. This showed that combining music with exercise promotes both mood and physiological excitation (Enoki, 1994). Ellis and Thayer found the same effect, that exercising while listening to music increases the ratio of low frequency to high frequency heart rate variability, a sign of sympatho-vagal balance or anxiety reduction. Thus, combining music with exercise helps boost mood but also promotes physiological excitation and enhance physiological activity (Ellis & Thayer, 2010).

Stress-induced physiological responses as measured by heart rate, blood pressure, and cortisol can also be prevented by exposure to relaxing music (Knight & Rickard, 2001). Music can be used to synchronize various body rhythms (such as breathing, heartbeat, speech, gait and blood flow). A slow flowing piece of rhythm that ranges 60-80 beats per minute (characteristic of relaxing music) can decrease sympathetic nervous system activity by decreasing heart rate and oxygen consumption (seen as a relaxation response) (Han, et al., 2010). Chafin et al. found that after completing a challenging three-minute mental arithmetic task and then either sit in silence or to listen to music (i.e. classical, jazz or pop), participants who listened to classical music had significantly lower post-task systolic blood pressure levels than did participants who heard no music (Chafin, Roy, Gerin, & Christenfeld, 2004). Perez-Lloret et al. studied the effects of different relaxing music styles (i.e. classical music, new age music, and romantic music) on the heart rate variability (part of the autonomic nervous system) by exposing participants sequentially to a silence period or to three melodies in these music styles in a random fashion while seated and hooked up to an electrocardiogram (ECG) machine. The study found that new age music induced a shift in heart rate variability from higher to lower frequencies, an indication of synchronization, independently on the music preference of the listener (Vigo, et al., 2014).

Although music has many different factors (e.g. tempo, melody, pitch), tempo is known to mediate physiological effects the most. Whereas faster music (regardless of genre) can cause increases in blood pressure, heart rate, and breathing rate, slower music causes decreases in these measures (Konopa & Honts). This can be applied to how fast-paced music acts as a “pump-up” before sports events to energize players and the crowd (Han, Kleifgen, Martin, & Zarling, 2011).

However, the effects of the combination of music and exercise on autonomic activity, while extensive, are poorly understood (Jia, Ogawa, Miura, Ito, & Kohzuki, 2016). Although a few studies have reported that listening to sedative music (i.e., slow tempo, legato phrasing, minimal dynamic contrasts) can lead to decreased heart rate, respiration rate, and blood pressure, these effects were inconsistent (Ellis & Thayer, 2010). Music perception involves complex brain functions underlying acoustic analysis, auditory memory, auditory scene analysis, and processing of musical syntax and semantics while also affecting emotion, the autonomic nervous system, and the hormonal and immune systems. Effects of music perception on activity of the autonomic nervous system have mainly been investigated by measuring electro dermal activity and heart rate, the number and intensity of reported ‘shivers’ and ‘chills’, and variations of (salivary) immunoglobulin A concentrations (Koelsch, 2011).

Combining movement and music has therapeutic effects such as on improving gait

Neurologic music therapy (NMT), which was developed in the early 1990s, is a set of research-based methods for the therapeutic application of music to cognitive, sensory, and motor function deficits related to neurologic disease. It seeks to find the direct connections between the regions of the brain where sound processing and motor system control both occur. It differs from conventional music therapy, which uses more of a social/psychological/emotional interpretive approach to music. NMT uniquely uses music and rhythm to build connections and stimulate the brain to reach functional goals (Gargiolo, 2015).

When the NMT technique uses rhythmic stimuli to work with gait, it is called rhythmic auditory stimulation (RAS), which uses rhythmic cues either as standalone metronome beats or metronome beats embedded in music, to direct gait parameters such as cadence, stride length, velocity, and symmetry, and enhance walking tempo, balance, and control of muscles and limbs. With RAS, participants listen to music with a strong rhythmic pulse while walking to enhance walking tempo, balance, and control of muscles and limbs. Motor benefits for patients with Parkinson’s disease, cerebral palsy, Alzheimer’s disease, and stroke have been found in both gait studies and modern Laban dance movement exercise programs using RAS. Most forms of RAS instruct patients to synchronize movements in time with the “beat,” or perceived pulse, in music. The beat is a regularly recurring perceived salience that arises in response to rhythm and music (Meyer and Cooper, 1960; London, 2012). The music piece is either 2/4 or 4/4 meter, which is a simple and symmetric rhythm of beats that is easy to walk to. The tempo is set at a target speed that the person needs to aim their movement in order to reach a speed that matches their predetermined normal stepping. Some example songs commonly used for gait RAS are Scott Joplin's "The Entertainer", Henry Mancini's "Baby Elephant Walk", "I've Been Working on the Railroad", Sir Edward Elgar's "Pomp & Circumstance", Ludwig van Beethoven's "*Für* Elise", and ABBA's "Dancing Queen".

When selecting music, it is important to focus on the aspects of it being predictable and having a salient beat (Gargiolo, 2015). Marches are known to lift mood and activate the listener, oftentimes using what is called back phrasing where off beats or syncopations occur before or after the beat to let the body part anticipate movement and land on the correct beat. This is called anticipatory syncopation (Maguire, 2014). RAS can enhance gait training (e.g. cadence, velocity, stride length) in patients following stroke (Hayden, Clair, Johnson, & Otto, 2009). Although RAS can incorporate music, only inconclusive results have been found for its benefits for mood. Since music is known to have a strong effect on mood, the music component of RAS should be further analyzed and enhanced with music therapy research to encourage mood benefit (Nombela, 2013).

A previous study looked at restoring nonlinear measures (fractal scaling of inter-stride interval gait variability) of gait by using rhythmic auditory stimulus in young healthy adults. The researchers believed that, when music was played, participants walking would synchronize their inter-stride interval of gait to be a multiple of the inter-beat interval of the piece, explaining why people unconsciously move to the beat of the music. The researchers manipulated the music of “Fur Elise”, using the mean and standard deviation of the inter-beat interval to match four different conditions of varying entropy: the preferred walking speed of each participant when there was no stimulus, a metronome, fractional Gaussian white noise, and a Lorenz system of equations that generated entropy values between periodic and random dynamics. Participants initially walked on a treadmill at their preferred walking speed for five minutes without a stimulus. Next, each participant completed five minutes of treadmill walking with the particular condition stimulus, then 5 minutes of seated rest. The four conditions were randomized in the order they were presented. The researchers performed trend analysis to see if there was a relationship between the entropy of the signal condition and the fractal scaling of the stride interval variability. A quadratic trend with an inverted U shape was found across conditions ordered in increasing entropy. Thus, they concluded that as the entropy of the driving signal increased monotonically from periodic to chaotic to random dynamics, the structure of stride time variability went from uncorrelated to persistent fractal scaling then back towards uncorrelated. ANOVA found no significant differences in alpha values between conditions. This was believed to be due to the stationary constraint of the treadmill (Hunt, et al.).

This same research group from the University of Nebraska continued their interest in exploring gait variability and therapy for aging populations, testing both young and elderly participants by having them walk on a treadmill for 5 minutes while listening to white noise, a chaotic rhythm, a metronome, and no auditory stimulus (Kaipust, et.al). The researchers calculated stride length, step width, and stride intervals for all conditions, then used detrended Fluctuation Analysis to find that an inverted U-shape described the relationship between gait variability and the structure of the auditory stimulus for the elderly group, but not for the young group. Thus the gait of the older participants could be manipulated using auditory stimuli. The main outcomes focused on restoring optimal gait variability through the predictability and complexity of the walking task. The task involved participants initially walking on a treadmill for 8 minutes to determine their natural walking speed. Next they walked at this natural walking speed under the four auditory conditions of white noise, a chaotic rhythm, a metronome, and non-stimulus for 6 minutes. This study found an inverted U-shape relationship between the temporal structure of auditory stimulus ordered along the predictability and complexity continuum (Kaipust, et.al).

Tying together the different techniques of Rhythmic Auditory Stimulation (RAS) and music therapy could be a potential treatment for anxiety. This project will look at the effect that these techniques have on anxiety.

Beat perception and familiarity with music affecting gait

Individual differences in beat perception affect gait when synchronizing footsteps to music and have implications for using music in gait rehabilitation. Music and rhythm engage the motor system via connections between the auditory and motor areas of the brain.

Pulse is a regular periodic pulse that defines the tempo of the music and is what people are able to synchronize their movements to. Slight deviations from this main framework beat create the foundation of different music styles. One of these deviations, groove, is the experience of wanting to move when hearing music, such as snapping fingers or tapping feet (Fitch, 2016). Incorporating groove into music involves having a consistent and easy to notice tempo and meter (which determines when dancers start and end their movements) (Fitch, 2015a). Although groove is operationally defined as how much music evokes the desire to move, groove has also been consistently associated with greater beat salience. High-groove music elicits higher arousal as well as a positive affective state (Madison, 2006). Researchers have also assessed how initially familiar and unfamiliar low-groove and high-groove music affected synchronization accuracy and gait in healthy individuals. They also experimentally increased music familiarity using repeated exposure to initially unfamiliar songs. Overall, familiar music elicited faster stride velocity and less variable strides, as well as better synchronization performance (matching of step tempo to beat tempo). High-groove music, as reported previously, led to faster stride velocity than low-groove music (Leow, Rinchon, & Grahn, 2015).

Beat perception neuroscience, history, and application to music production

Beat perception is a complex brain function involving interactions between auditory and motor planning regions, particularly the stimulation of periodic movement in motor planning regions providing a neural signal that helps the auditory system predict the timing of upcoming beats. Pure perception of a beat (i.e., in the absence of any overt movement) engages motor areas of the brain, including premotor cortex, the basal ganglia (putamen), and supplementary motor area.

There is also an evolutionary aspect to beat perception, since there are stronger connections between auditory regions and motor planning regions via the parietal cortex in humans than in non-human primates, likely due to the evolution of vocal learning. Basic neural resonance theory claims that beat perception arises when non-linear oscillations in the nervous system entrain to (oscillate in synchrony with) external rhythmic stimuli. Musical beat perception involves perceiving a periodic pulse in temporally complex sound sequences. Listeners often express their perception of the pulse by moving rhythmically in synchrony with the pulse, e.g., via head bobbing, foot tapping, or dance. Specifically, taps fall very close to beats in time, showing that the brain makes highly accurate temporal predictions about the timing of upcoming beats.

Humans perceive beats in a range of about 250 ms – 2 s, though intervals between about 400 and 1200 ms give rise to the strongest sense of beat, and humans show a preference for beat periods around 600 ms. Therefore, in dance music, pieces tend to have tempi between 94 and 176 beats per minute (BPM). While much popular music is composed in such a way as to guide the listeners' beat perception (e.g., by physically accenting the beats or emphasizing them with grouping boundaries, instrumentation, or melodic contours), beats are often arranged in patterns that create higher-level periodicities. This hierarchical patterning of beats is referred to as meter. (Patel & Iversen, 2014).

Purpose and Hypotheses

The main purpose of this thesis was to find a more quantitative and systematic method of quantifying the effects of music on movement patterns as well as the interactive effects of both on anxiety levels. This would serve to start bridging the gap between kinematic studies and creative art therapy studies.

Based on the feedback and observations made during a pilot study completed in fall 2015, a study proposal was submitted to the Institutional Review Board (IRB) in spring 2016. This project examined whether a RAS protocol incorporating music and movement therapy techniques had a significantly different effect on a specified movement pattern and on anxiety, compared to the same movement protocol performed without music. This project examined both the effect that music has on movement patterns and anxiety as well as the relationship between movement patterns and anxiety if both factors were affected. It was expected that, compared to movement performance in silence, movement done while music with a pronounced beat was playing would show greater coincident rhythm. Furthermore, it was expected that anxiety levels, both reported and assessed physiologically, would decrease. Like Kaipust, et. al, participants in this study were not explicitly instructed to walk to the beat of the rhythm. Two differences between that experiment and this one were that in that experiment, subjects each walked to the specified auditory stimulus for 1 minute for familiarization and listened through a set of headphones. In this experiment, there was no familiarization period and the sound was played on speakers.

Hypotheses for this project included the following:

1. Compared to the silent condition, it was expected that anxiety score differences before and after completing the movement task done with music would be larger, indicating a larger reduction in anxiety when music was played.
2. Compared to the silent condition, it was expected that, pulse rate and oxygen saturation levels would be lower for the music condition, indicating a larger reduction in anxiety when music was played.
3. For the music condition, there would be a synchronization of movement to the beat and more regular timing in movement pattern than in the silent condition.
4. Comparing the results for each participant for both conditions, there would be a positive correlation between the change in anxiety and change in kinematic movement pattern variables.
5. This project combined the interaction of anxiety and movement. It was felt that participants with the largest change in anxiety would have a larger change in movement between the two sessions. Conversely, participants who had slight anxiety level change would also have slight movement change between the two sessions.

Methods

Data collection

Data were collected from 11 volunteer participants (5 female, 6 male, mean age 23) in accordance with an IRB approved protocol. Participants were screened to exclude individuals with previous organized experience with dance or dance aerobics after the age of 10 (e.g., school dance team, private dance studio training) and to require being healthy and without a history of neurological disorders. Musicians of any level of expertise were allowed to participate since this study involved whole body movement response to music, not fine motor response (e.g., finger tapping) that might be involved in playing an instrument. After data were collected, all videos, questionnaires, consent forms, and data collection sheet for each participant were organized by the ID number assigned to each participant.

All testing took place in the Developmental Motor Control Lab, BEL 546B, at The University of Texas at Austin. Each participant came to the lab for two approximately 90 minute sessions separated by 1-2 days. A VICON motion capture system and body markers placed on critical points of the body were used to record precise kinematic data from movement. After an initial 5 minute seated rest period, anxiety level was assessed by having participants complete a STAI-6 questionnaire and by measuring pulse rate and oxygen saturation readings using a pulse oximeter. The State-Trait Anxiety Inventory (STAI) is a questionnaire commonly used in applied psychology research that measures both state anxiety (how one feels at the moment) and trait anxiety (how one generally feels) with questions alternating between anxiety-present and anxiety-absent. Shorter versions of the STAI are available for situations with time constraints (Marteau, 1992). This study used a 6 item STAI instead of the full 40 item version because of the constraint of time and the non-clinical population being tested.

A total of 14 passive infrared light reflecting markers were then placed on the participant’s body landmarks (Figure 1).

1. Right third finger knuckle
2. Left third finger knuckle
3. Bony prominence on top of right shoulder
4. Bony prominence on top of left shoulder
5. Right hip (trochanter)
6. Left hip (trochanter)
7. Right knee (patella)
8. Left knee (patella)
9. Bony prominence on outside of right ankle
10. Bony prominence on outside of left ankle
11. Back of right heel
12. Back of left heel
13. Right big toe metatarsal
14. Left big toe metatarsal

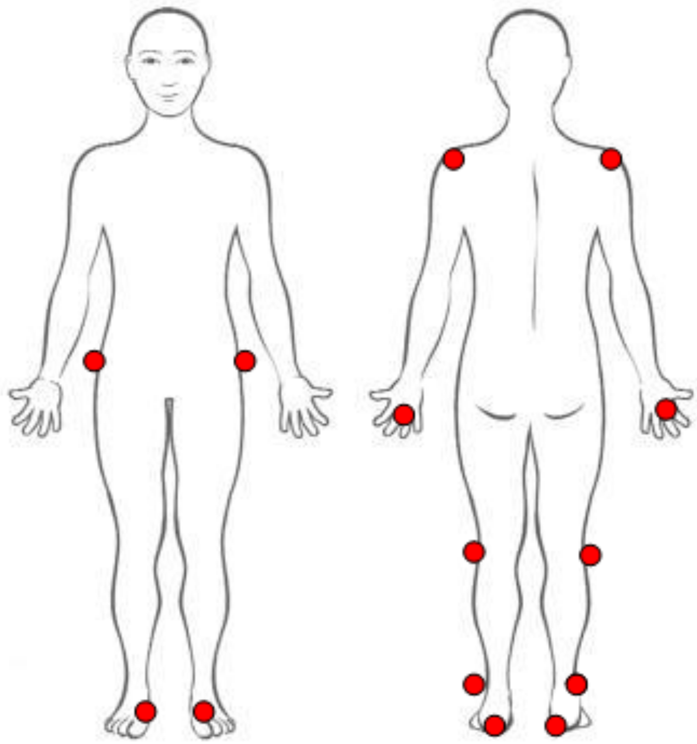

Figure 1: Body marker diagram with the 14 red circles marking the location of the reflective markers used for motion capture. From: CMU Graphics Lab Motion Capture Database Marker Placement Guide.

The task consisted of walking and also a whole body structured movement sequence. During one session, each participant performed this movement task in silence, without any background noise. During the other session, this same movement task was performed while a song played. The song played during the music session was the first portion of an instrumental version of Kylie Minogue's "Get Outta My Way" with the tempo set to 114.6 bpm. The song and tempo were selected for easily identifiable beats, simplicity in structure, clear progression, high "groove factor", and a rhythmic pattern close to purposeful walking speed (fandom).

The order of the two sessions was assigned to participants in a pseudorandom manner, so that at least five had each session first. An initial instructional period allowed the investigator to teach the participant how to perform the movement task. An instructional video about the movement task was shown to each participant twice. The instructional video showed an experimenter completing the movement task in the testing space in silence. Then the participant completed a practice trial of the movement task in the dedicated space in silence. Then the instructional video was shown to the participant once more. The participant then completed another practice trial. This thorough instruction period was to help minimize uncertainty and anxiety about the movement task. With regard to questions about their performance of the movement task, participants were only told that the project was looking at their kinematic movement patterns when there was and was not music. Participants were told to focus on doing the proper movements and sequence of steps, not on the speed, accuracy and size of movements. For the session where music was played, each participant was instructed to listen to the music while completing the movement task. They were told that the experiment was examining whether the music had any effect on their movement (Figure 2).

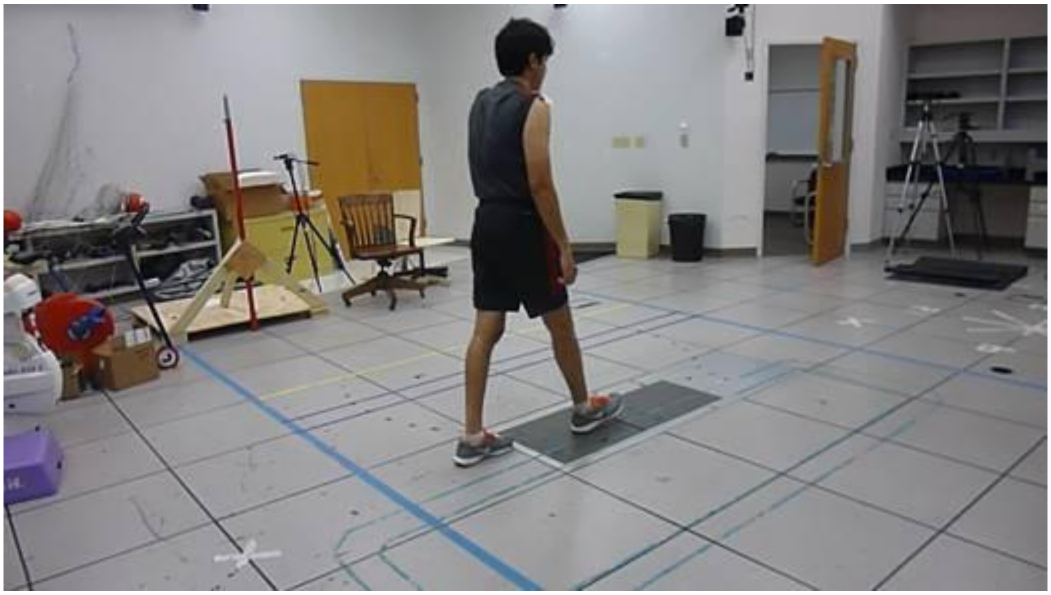

Figure 2: Experimental setup for collecting movement data. Each participant wore 14 body markers and first walked normally from the right white x to the left white x and back then completed a structured movement sequence from the right blue tape line to the left blue tape line and back. The distance between the blue tape lines was 10 feet.

For both sessions, each participant completed one practice trial in silence before two recorded trials. For both test sessions, before starting the movement task for each trial, the experimenter verbally led the participant through a 30 second deep breathing exercise while standing at the starting point. For the session without music, these 30 seconds were in silence. For the session with music, these 30 seconds were after the music had started playing. This period encouraged the participants' to attend to the task instructions and was designed to help them plan the movements to make during the trial. The guided instructions to use slow breaths was intended to help them maximize their brain oxygen gradient and help them relax and focus more on the task.

After the movement task, participants removed their body markers, sat, and had their pulse rate and oxygen saturation taken again immediately with the pulse oximeter. They then completed another STAI questionnaire to see how they felt after the movement task. In addition to these post-movement task measurements, participants completed a feedback questionnaire with free response questions about the session.

Data analysis

VICON data processing

The VICON motion capture system was used to collect kinematic data at 120 Hz. From the motion data (x, y, z coordinates of the 14 reflective markers), a number of kinematic variables were calculated. The music was fed into an A/D input channel of the computer (sample rate = 1200 Hz) to be time-synced to the motion data and for subsequent signal analysis to identify the music beat. The motion data were then exported in .csv (comma separated variable) format and both sets of data were imported into MATLAB.

Statistical Analysis

A 1 way ANOVA with 2 factors (condition and group) was done for the STAI data. The Post-pre STAI score differences for each condition (music or silent) were the dependent variables. For the movement data, the variation in movement (heels during walking and structured movement sequence as well as hands during structured movement sequence) was compared among subjects, with 2 factors (condition and group). The standard deviations for each subject for each condition (music or silent) were the dependent variables. Both analyses asked if there was an effect of music, if there was an effect of order, and was there an interaction, meaning, how did the effect of music depend on the testing order (Music 1^{st} or Music 2^{nd}).

Operational definitions

The movement task consisted of both the walking portion and the structured movement sequence portion. Each portion was examined independently. Each participant had two sessions, a first and a second, for testing. These sessions differed in the two testing conditions, music and silent. The movement task involved the participant moving back and forth across a room in a relatively straight line, along the y-axis of the VICON measurement system. The origin of the axes was at the center of the designated test space. Vertical movement was recorded in the z-axis. For gait analysis, heel strike was defined as the moment in time when the z component of the heel body marker first made contact with the ground (equal to the initial height of the heel when standing). Stride length was defined to include two steps, one for each leg. Stride length was measured from the right heel strike until the next right heel strike. Interstep interval was defined as the time between two consecutive heel strikes of the two legs during the walking portion and of the same leg during the structured movement sequence portion of the task.

Assumptions

For analyzing the movement task, the following assumptions were made:

- Participants would express intentional rhythmic movement the most in their heels and hands, thus these were the selected body markers analyzed.
- For the music condition, if participants were trying to move in sync in any

way to the music being played, their focus would be centered on the pronounced beat of the music instead of any other aspect of the song. Thus the time occurrences of this beat were used as when measuring rhythm with the music.

- Trial 2 for both sessions was used for analysis to account for learning and adjustment to the task. Trial 1 was analyzed only if trial 2 had missing data. This was done for Participant 6's second session.

Initial analysis and anxiety scoring

After the movement data had been reviewed in the VICON system and all corrections for proper marker detection throughout the trials made, the data file was exported to a .csv file. Both kinematic and music data ended when the movement task ended or shortly thereafter. Participants were told not to stress about getting the precise movement correct. For this reason, particularly on the structured movement sequence portion of the movement task, some participants did not fully complete the fourth step, but would instead blend it into turning around. If this appeared to happen or was not clearly distinguishable, these data were eliminated from analysis. The turning around portions of the movement task were excluded from movement analysis.

For this study, the z data for both hand markers as well as y data for both heel markers were analyzed, since there were easily visible inflection points in the kinematic data for these markers. X data were not analyzed because the movement was mainly along the y-axis and differences in the x direction would only be of interest if the project were looking at sway movement factors or balance kinematics. For specific body marker analysis, the z-axis movement of the hands and the y axis movement of the heels were examined for both right and left sides.

Trial 2 was used for each participant unless there was significant marker loss. Marker loss during turn around portions was ignored because data from this part of the movement were not analyzed.

Data were only analyzed for 9 of the 11 participants because for the other two participants there was either too much marker loss or movement that was too erratic. The kinematic data from the heels and hands of both sides were analyzed to characterize the temporal movement pattern. The right and left sides were studied separately and together. All feedback questionnaire results were consolidated and participant numbers (1-9) were listed as number responses for each question (see item A1 in Appendix A**).** The STAI questionnaires were then scored (see item A2 in Appendix A)**.**

Identifying frames of beat occurrence in music data

For the music data, because the music through speakers was also input to the computer, the music and movement were recorded on the same time scale. The song was adjusted to play at 114.66 bpm, so the beat/second rate was 1.911 beats/second or a beat tick every 0.522 seconds. The entire movement task duration was about 30 seconds. By comparing the music signal feed to the music signal when the song was examined in audio editing software, the beat waveforms and beat interval were identified.

Heel kinematic data analysis

The average interstep time was found for both conditions by looking at the heel strike. The movement from the two conditions was compared by looking at the variability of this time throughout the trials. For the movement performed in the music condition, the music sound file with its pronounced beat was superimposed to see if the stop and start of each heel strike synchronized with the music (either occurring prior to the beat in an anticipatory fashion or after the beat in a delayed fashion).

For both the right and left heel movement data in the y axis, the frame and position data were isolated for selected “shoulder” points throughout the entire movement sequence. Shoulders were where, for that heel marker, the subject would not have any movement in the y direction, and thus the kinematic data would appear as a plateau. The isolated points were located where these shoulders began and ended. For the structured movement sequence portion of the movement task, the frame and position data when the participant was making a new leading step were highlighted as well. Next, a calculated column was created to show the frame and position difference between steps throughout the entire movement sequence.

For the trials during which music was played, a column of the time frames where the music beat was occurring was shown. Next, another calculated column was made to find the frame difference between the highlighted movement frames (when participants were stepping/heel striking) and when the closest music beat was happening. The music beat interval was 63 frames. Since the participants might not step to every consecutive beat, the closest music beat frame was selected for this comparison. This allowed determination of how closely the selected movement points for aligned to the beat. Therefore, during the walking portion of the movement task, getting consecutive numbers meant that the participant was aiming to heel strike on consecutive beats. The movement-music beat difference column and selected music beat frame index column were two methods to show the level of rhythm in participants.

Hand kinematic data analysis

For the hand data, 8 points were identified in the z-axis (vertical) data during the structured movement sequence. These frames were when the hand markers hit the initial peak positions and when they hit the initial descent positions for each hand.

Next, these 8 frame points were compiled for both hands for both selected trials for each condition for all participants. For each trial, the difference between the right and left hand frame points was taken. This calculation was only done for the structured movement sequence and not for the walking. The size of this difference suggested how out of sync the right and left hands were for the 8 selected positions. Frame, not position, was studied because participants were non-dancers and were instructed not to focus on exact position but just time of position. The highest ‘score’ was when the hands were raised to a “T” position, the third and seventh selected points. This is likely because, during this time, the participant was focusing on turning to face the wall on the left. These two points were further examined. For the first raise to a “T” position, 5/19 times the left hand went before the right. For the second raise to a ‘T’ position, 5/18 times the left hand went before the right. This makes sense, since the left was the back hand when facing the left side, yet stepping with the right foot. If the hand difference was positive, then the left came after right (L-R); if negative, then left came before the right. Hand position difference was dependent and hand position number was independent.

For the 8 selected points in the hand movement, the frame and position data from the left and right were averaged together to create a single set of data to perform a similar set of comparisons to that employed with the heel data (described above). Averaging the left and right hand movements was deemed valid because the movement task instruction in the instruction video stated to move the hands together. Once averaged, the same calculated columns found the frame and position difference between each point, the frame difference between the closest music beat and movement point, as well as a column of selected music beat frame indexes.

The average of differences between the 8 points was checked to determine whether there were statistically significant differences between hands. A univariate general linear model to compare the means was performed. For statistical analysis of the hand movement, a univariate ANOVA test was performed in SPSS to ask if the average of frame differences between hands differed between the selected 8 movement points. For this analysis test, the frame difference between the left and right hand was the dependent variable and the hand position (1-8) was the independent variable. Despite the fact that hand position points 3 and 7 had the highest averages, there were no significant differences to be found ($p = 0.893$ when alpha = 0.05) among the 8 group means in the univariate ANOVA test.

Results

The data collected revealed a high level of individual variation in all collected measures. Therefore, in addition to analyzing treatment condition differences, in some cases a subset of participants with similar changes in anxiety were identified and examined to see if the relationships between their movement patterns and music or anxiety were similar.

Part I: Did movement have an effect on anxiety? If so, then for which participants in particular? How did order of condition testing affect this difference?

STAI scores were selected to be the measure of anxiety because they appeared to be most responsive to the treatment interventions. Changes in anxiety from pre-movement to post-movement varied across all participants (Figure 3). Therefore participants with the largest anxiety change in STAI scores from before to after the movement task were isolated to be examined in depth.

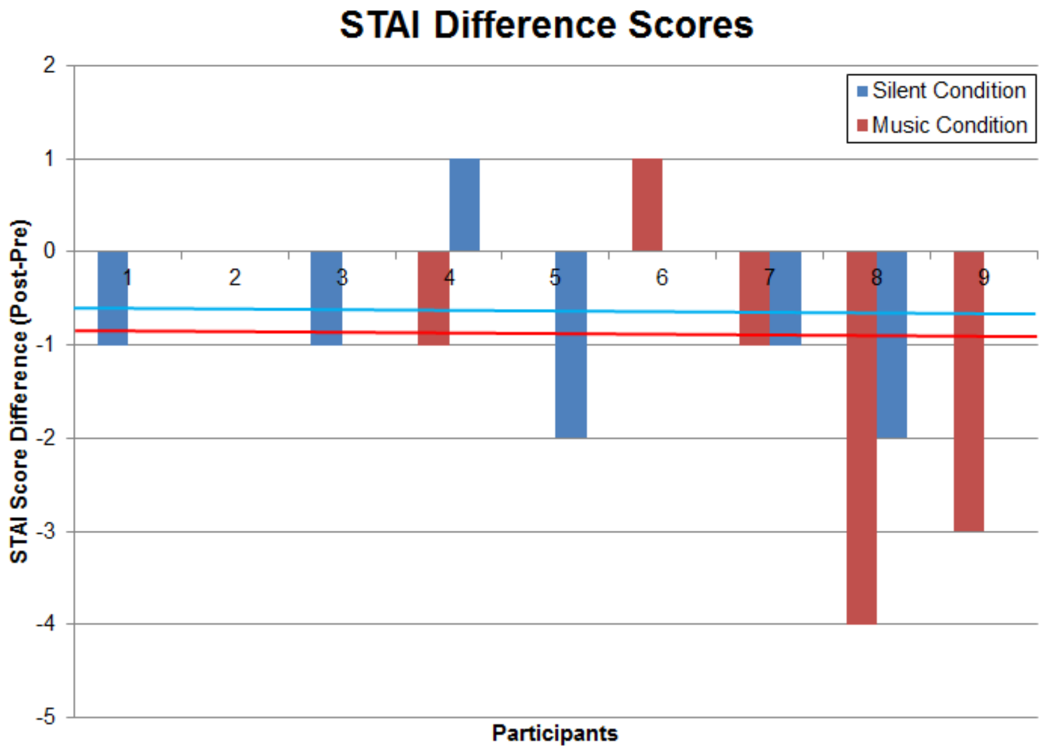

Figure 3: The difference (post-movement task score minus pre-movement task score) in STAI scores for both sessions (music and silence) of all participants. Negative bars indicate a decrease in anxiety and positive bars indicate an increase in anxiety. The blue and red horizontal bars are the average STAI score differences during the silent and music conditions, respectively. For the univariate ANOVA, no significant differences were found between the music 1st and music 2nd group as well as music or silent condition.

Based on the data in Figure 3, Participants 5, 8, and 9 were selected for further analysis because their STAI score differences were greater than 1 in magnitude. All three of these participants had the same test order: music first and then silence. Participant 5's larger STAI score difference occurs in its silent condition, while Participant 8's larger STAI score differences occur during both conditions, and Participant 9's larger STAI score difference occurs during the music condition. It appeared that movement helped reduce Participant 8's anxiety (blue bar), but that music helped this to a greater extent (larger red bar). The two positive difference bars, for Participants 4 and 6 were also in the music 1st group. For Participants 4 and 6, who had positive STAI score differences (meaning that their anxiety went up), no conclusion could be made about whether taking away music for the second session increased their anxiety. Seven different bars with no value can be seen. Four of these belong to participants in the music 2nd group and three of these belong to participants in the music 1st group. Furthermore, because Participants 4, 8, and 9 had larger negative bars for the music condition, you could say that movement with music playing had a bigger effect on anxiety than movement in silence did for these participants. The opposite applies to Participants 1, 3, 5, and 6. No change in anxiety between the two conditions was observed for Participants 2 and 7.

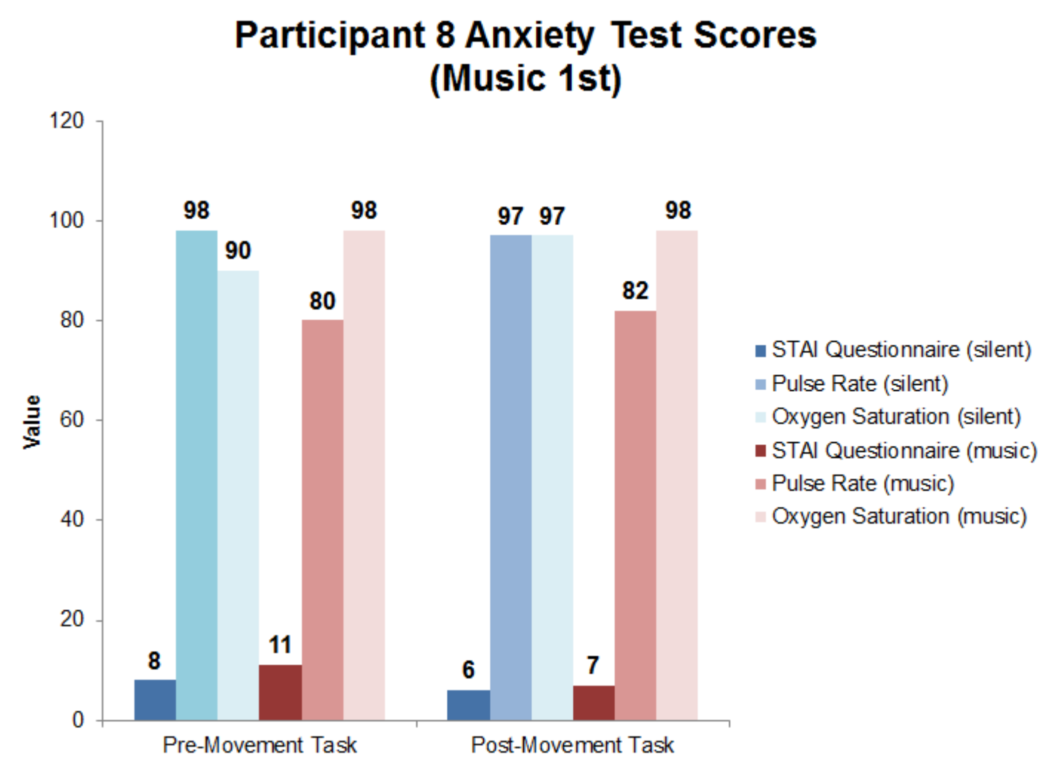

Figure 4: Individual anxiety measurement profile for Participant 8, part of the music 1st group. The music and silent conditions, as well as pre-movement and post-movement task measurements, are reported separately. Actual measurement values are shown at the top of each bar.

In Figure 4, a decrease in STAI scores between pre- and post- movement task was seen for both conditions, suggesting a decrease in anxiety level. For pulse rate, a slight decrease was seen in the silent condition but a slight increase was seen in the music condition. For oxygen saturation, an increase was seen in the silent condition (suggesting a decrease in anxiety) but no change was seen in the music condition. Based on the STAI scores, movement without music lowered anxiety level for Participant 8 and movement with music lowered anxiety level even more.

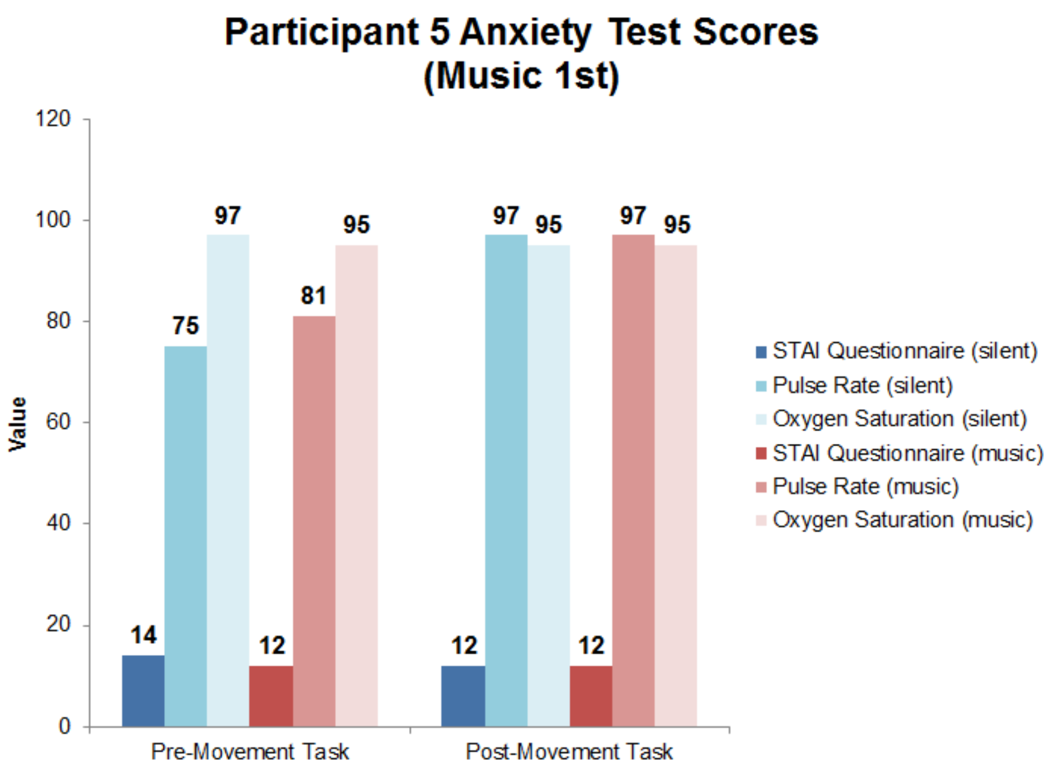

Figure 5: Individual anxiety measurement profile for Participant 5, part of the music 1st group. The music and silent conditions, as well as pre-movement and post-movement task measurements, are reported separately. Actual measurement values are shown at the top of each bar.

In Figure 5, a decrease in STAI scores between pre- and post- movement performance was seen for the silent condition while no change was seen in the music condition. For pulse rate, an increase was seen in both conditions. For oxygen saturation, a slight decrease was seen in the silent condition but no change was seen in the music condition. Based on the STAI scores, Participant 5 showed that movement without music lowered anxiety level and that movement with music had no impact on anxiety level.

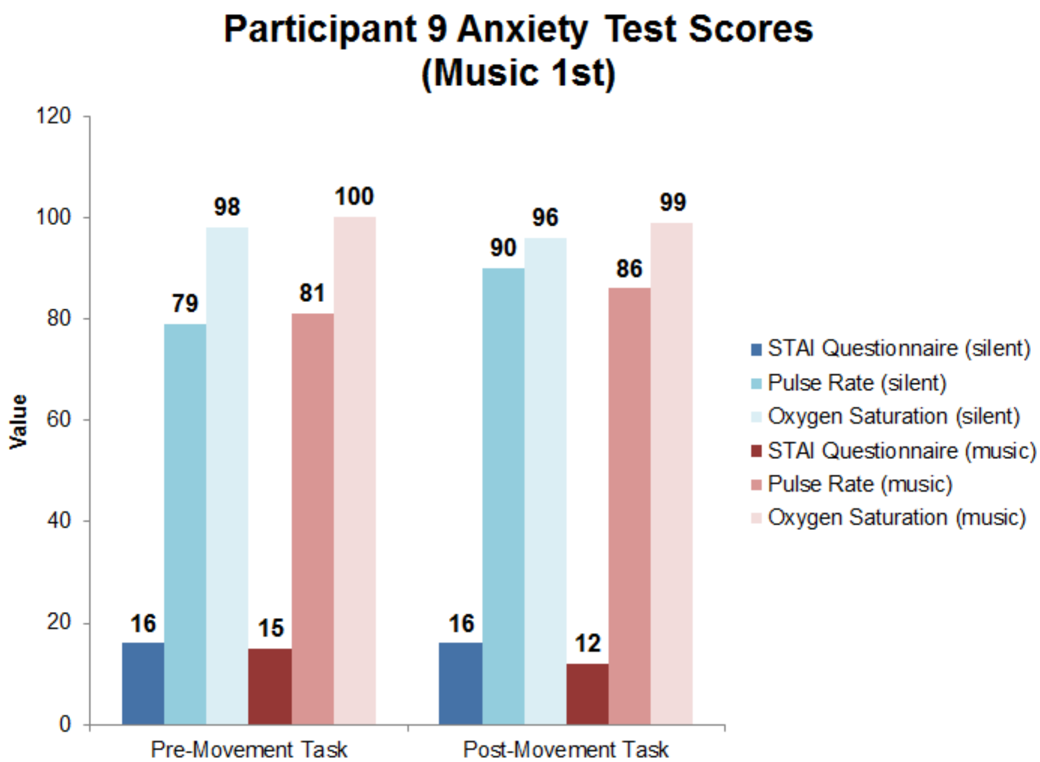

Figure 6: Individual anxiety measurement profile for Participant 9, part of the music 1st group. The music and silent conditions, as well as pre-movement and post-movement task measurements, are reported separately. Actual measurement values are shown at the top of each bar.

In Figure 6, no change in STAI scores between pre- and post- movement task can be seen for the silent condition while a decrease was seen in the music condition. For pulse rate, an increase was seen in both conditions. For oxygen saturation, a slight decrease was seen in both conditions. Based on the STAI scores, Participant 9 showed that movement without music had no impact on anxiety level and that movement with music decreased anxiety level.

If some differences between conditions: Did movement during music change because listening to music relaxes you in general or was the participant intentionally trying to be with the music?

Observations from the feedback questionnaire (Appendix A) for the music session showed that, compared to the other two highlighted participants, Participant 8 focused on the left-right aspect of the movement task instead of the movement sequence as a whole.

Different hypotheses were made for the effect that the intervention (movement task with and without music) would have on the three anxiety measurements. The STAI score higher results indicating a higher level of anxiety. While it is unclear how heart rate synchronizes to the tempo of the music being played, it was expected that pulse rate would increase due both to anxiety and to completing the low-intensity exercise of the movement task. Normal arterial oxygen is approximately 75 to 100 millimeters of mercury (mm Hg). Decreased oxygen saturation is found among people with stress and anxiety (Dousty, Daneshvar, & Haghjoo, 2011).

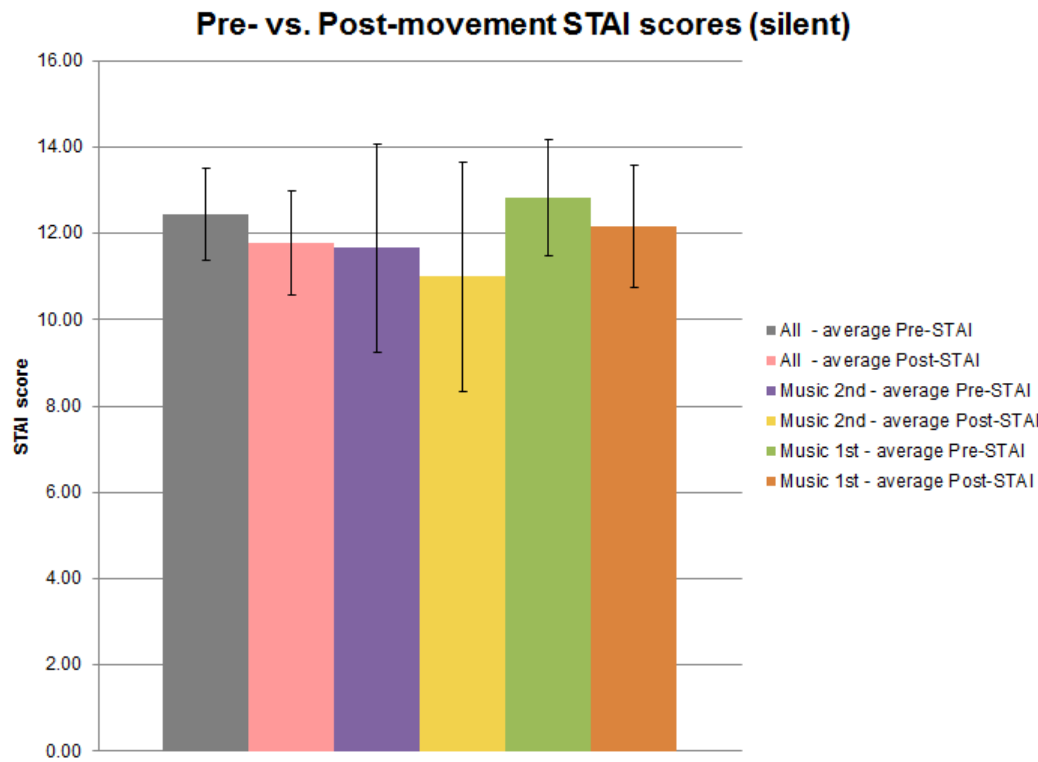

Figure 7: Average pre- and post-movement task STAI scores for all participants, participants in the music 2nd group, and participants in the music 1st group during the silent condition. Bars are standard error. Music second means that the participant's first session was silent and second session was music. Vice versa for music first.

In Figure 7, for all participants (grey and pink bars) during the silent condition, an average decrease is seen between pre- and post- STAI scores, indicating, on average, that the movement task without music lowered anxiety. This figure plots the Music 2nd group's (purple and yellow bars) first session and shows a large variation in standard error and an average decrease from pre- to post- STAI scores. This figure plots the Music 1st group's (green and orange bars) second session and also shows an average decrease from pre- to post- STAI scores.

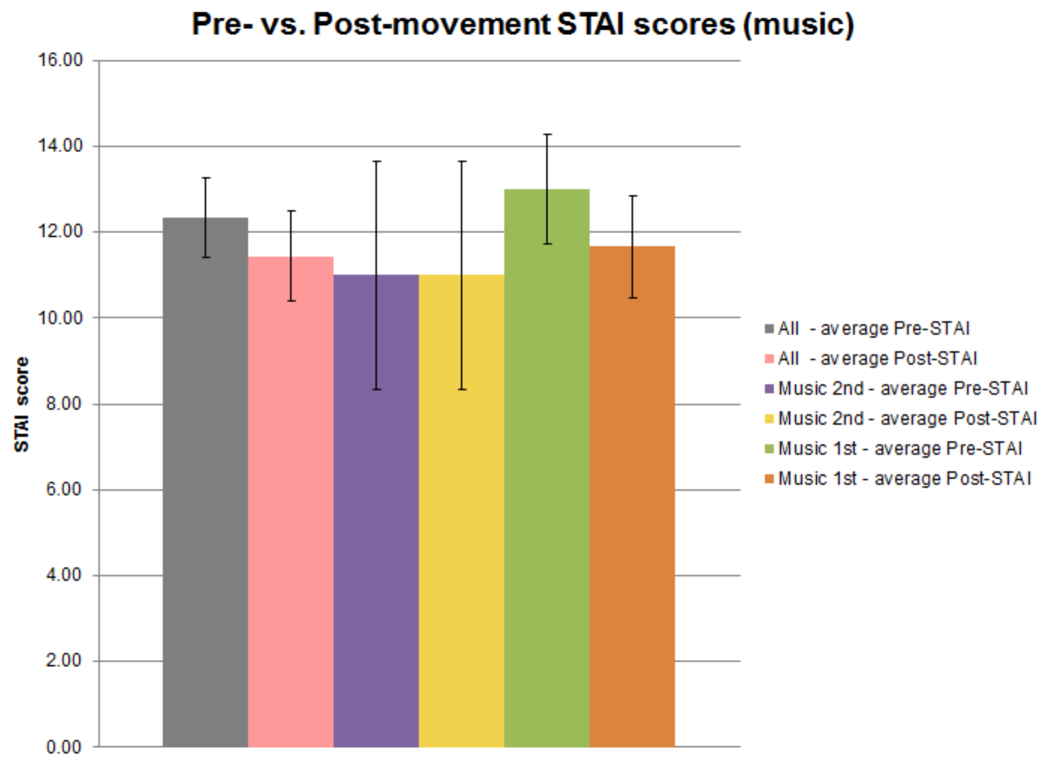

Figure 8: Average pre- and post-movement task STAI scores for all participants, participants in the music 2nd group, and participants in the music 1st group during the music condition. Bars are standard error. Music second means that the participant's first session was silent and second session was music. Vice versa for music first.

In Figure 8, for all participants (grey and pink bars) during the music condition, an average decrease is seen between pre- and post- STAI scores, indicating, on average, that the movement task with music lowered anxiety. This figure plots the Music 2nd group's (purple and yellow bars) second session and shows a large variation in standard error and no change from pre- to post- STAI scores. This figure plots the Music 1st group's (green and orange bars) first session and shows an average decrease from pre- to post- STAI scores. The difference in standard error bar sizes could be due to the difference in sample sizes between the Music 1st group (n=6) and the Music 2nd group (n=3).

When looking at the average pre- and post-movement task pulse rate values for all participants (see item B1 in Appendix B), for all participants (grey and pink bars) during the silent condition, an average increase is seen between pre- and post- pulse rate values, which could be due to having completed a low-intensity movement task. Item B1 plots the Music 2nd group's (purple and yellow bars) second session and shows an average decrease from pre- to post- pulse rate values. Item B1 plots the Music 1st group's (green and orange bars) first session and shows an average increase from pre- to post- pulse rate values.

When looking at the average pre- and post-movement task pulse rate values for all participants (see item B2 in Appendix B), for all participants (grey and pink bars) during the music condition, an average increase is seen between pre- and post- pulse rate values, which could be due to having completed a low-intensity task. Item B2 plots the Music 2nd group's (purple and yellow bars) second session and an average increase from pre- to post- pulse rate values. Item B2 plots the Music 1st group's (green and orange bars) first session and also shows an average increase from pre- to post- pulse rate values, but less so than the Music 2nd group.

When looking at the average pre- and post-movement task oxygen saturation values for all participants (see item C1 in Appendix C), for all participants (grey and pink bars) during the silent condition, no change was seen between pre- and post- oxygen saturation values. Item C1 plots the Music 2nd group's (purple and yellow bars) second session and an average decrease from pre- to post- oxygen saturation values. Item C1 plots the Music 1st group's (green and orange bars) first session and also shows an average increase from pre- to post- oxygen saturation values. The small scale size and large standard error values should be noted.

When looking at the average pre- and post-movement task oxygen saturation values for all participants (see item C2 in Appendix C), for all participants (grey and pink bars) during the music condition, an average decrease was seen between pre- and post- oxygen saturation values. Item C2 plots the Music 2nd group's (purple and yellow bars) second session and an average decrease from pre- to post- oxygen saturation values. Item C2 plots the Music 1st group's (green and orange bars) first session and shows an average decrease from pre- to post- oxygen saturation values. The small scale size and large standard error values should be noted.

Items B1, B2, C1, and C2 in Appendices B and C show the pulse rate and oxygen saturation levels, representing the physiological response of the cardiovascular system and metabolic rate, increasing due to completing a low-intensity activity. Despite the movement task being so short and of low intensity, and the difference between pre- and post- movement task measures not being statistically significant, the effect of physical movement is evident in the data from the pulse rate and oxygen saturation measures. This may be in part due to the competing influences of physical activity and anxiety reduction. While music had the potential to cause a differential drop in pulse rate after the movement task, because of the intervening variable of physical activity that affects pulse rate and oxygen saturation, more emphasis was put on the STAI data when assessing anxiety reduction.

Part II: Movement analysis: How did the combination of music and movement affect anxiety?

The previous section discussed how the movement task reduced anxiety for some participants. The literature in the introduction stated that listening to music can affect anxiety. The next part of the analysis studied how combining playing music and moving affects anxiety. Kinematic data for the heels and hands (e.g. interstep intervals) were looked at for both the silent and music condition. In order to determine whether music had an effect on the participants, a possible effect on the movement pattern was sought out, specifically whether the movement rhythm was more consistent or was synchronized to the beat of the music. To assess the regularity of the movement rhythm, the standard deviation of the heel strike interstep interval for both the heel and hand kinematic data was calculated. Because the effect on anxiety was different for when there was and was not music, the movement data was looked at to see if it was different between the two conditions (silent and music).

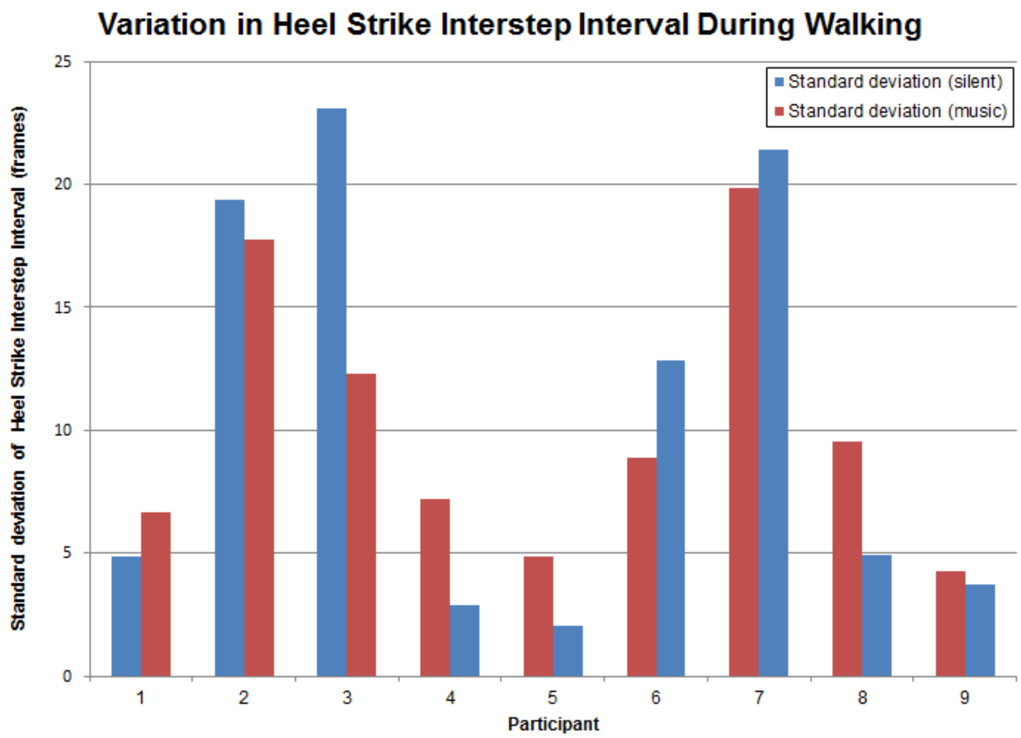

Figure 9: Standard deviation of heel strike interstep interval (heel strike to heel strike for each step) for both conditions (silent and music) during the walking portion of the movement task for all participants. Colors of the bars indicate the testing condition (blue for silent, red for music) and order of bars for each participant indicate the order of testing. For the univariate ANOVA, no significant differences were found between the music 1st and music 2nd group as well as music or silent condition.

Considering the standard deviation bars as a measure of movement consistency, on average when looking at the entire group, movement with music did result in less variability, Looking at the music 2nd group, on average, there was less variability when music was added (lower standard deviation for second red bars); whereas the music 1st group, on average, showed greater variability in the music condition (higher standard deviation for first red bars). For the music condition, differences between the average interstep and occurrence of the music beat will be looked at below. Participant 5 had the least variability with the lowest standard deviation for the silent condition and second lowest for the music condition. Participant 9 had the least variability for the music condition. Participant 8 fell towards the average of the entire group.

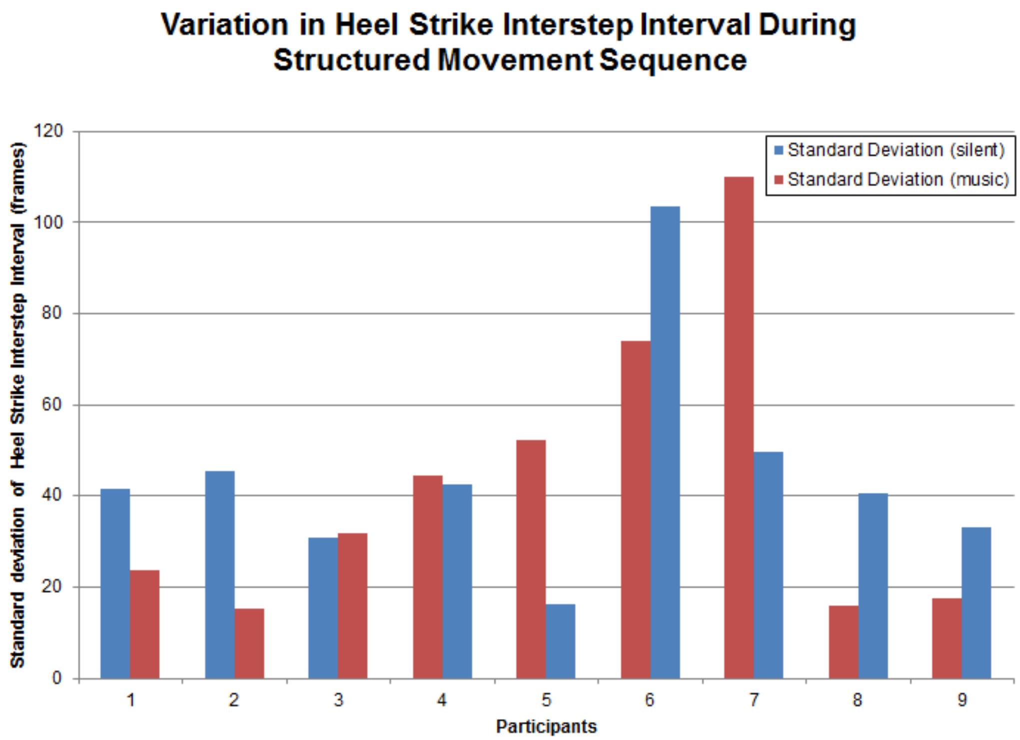

Figure 10: Standard deviation of heel strike interstep interval (heel strike to heel strike of the same foot) for both conditions (silent and music) during the structured movement sequence portion of the movement task for all participants. Colors of the bars indicate the testing condition (blue for silent, red for music) and order of bars for each participant indicate the order of testing. For the univariate ANOVA, no significant differences were found between the music 1st and music 2nd group as well as music or silent condition.

Considering the standard deviation bars as a measure of movement consistency, on average, movement with music did result in less variability, when looking at the entire group of participants. For the music 2nd group, there was less variability, on average, when music was added, whereas for the music 1st group, there was more variability in the music condition. For the music condition, differences between the average interstep and occurrence of the music beat will be looked at below. Participant 5 had the least variability (lowest standard deviation) for the silent condition. Participant 8 had the second least variability for the music condition. Participant 9 had lower variability in movement for both conditions when being compared to the entire group.

The signed and absolute value difference scores (number of frames between music beat and movement event) were used to grade the participant's synchronization with the music beat. The absolute score difference between the movement event frame and the selected closest music beat frame was calculated to determine how close to the beat each participant movement was. The signed standard deviation of this score tells how much this varied. Ignoring the sign of the difference represents by how much the participant was missing the beat. The signed score difference reveals whether the participant tended to move before or after the beat. Similarly, the standard deviation of this score represents how much this varied. If the participant was perfectly hitting the selected movements at the same frame as the music beat (difference of 0), then they were considered to be fully synchronized.

In the movement data with music, what is relationship between the heel movement of the participant (during the walking and/or the structured movement sequence) to the beat of the music, either on, just before, or just after?

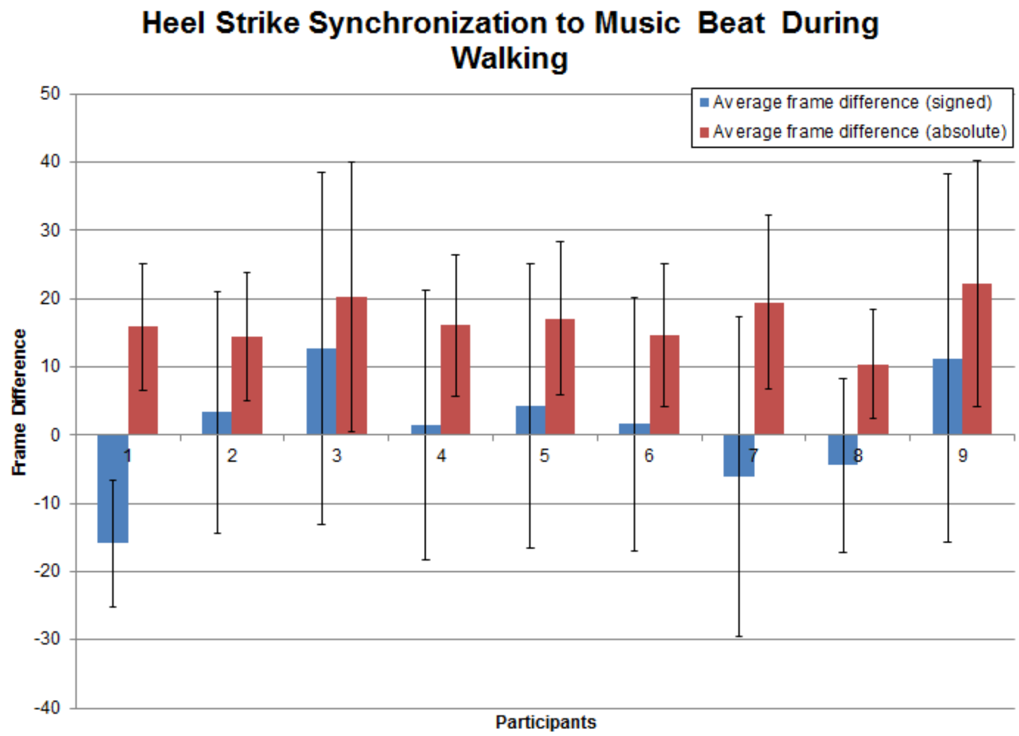

Figure 11: Average frame difference (signed and absolute) between heel strike and closest music beat with standard deviation error bars for the music condition during the walking portion of the movement task for all participants. For the signed (blue) measures, a positive value means that the heel strike occurred after the closest music beat frame, whereas a negative value means that the heel strike occurred before the closest music beat frame. For the absolute (red) measures, a smaller value means that, whether it was before or after, the heel strike was more synchronized with the closest music beat frame.

For the standard deviation of the signed frame difference (blue bars), participants 1 and 8 had the lowest level of variation and participants 3, 7, and 9 had the highest level of variation. For the absolute measures (red bars), representing closeness to the music beat, participant 8 (largest anxiety change) had the lowest average difference, indicating good synchronization with the closest music beat. Participants 3, 7, and 9 had the highest average difference (absolute).

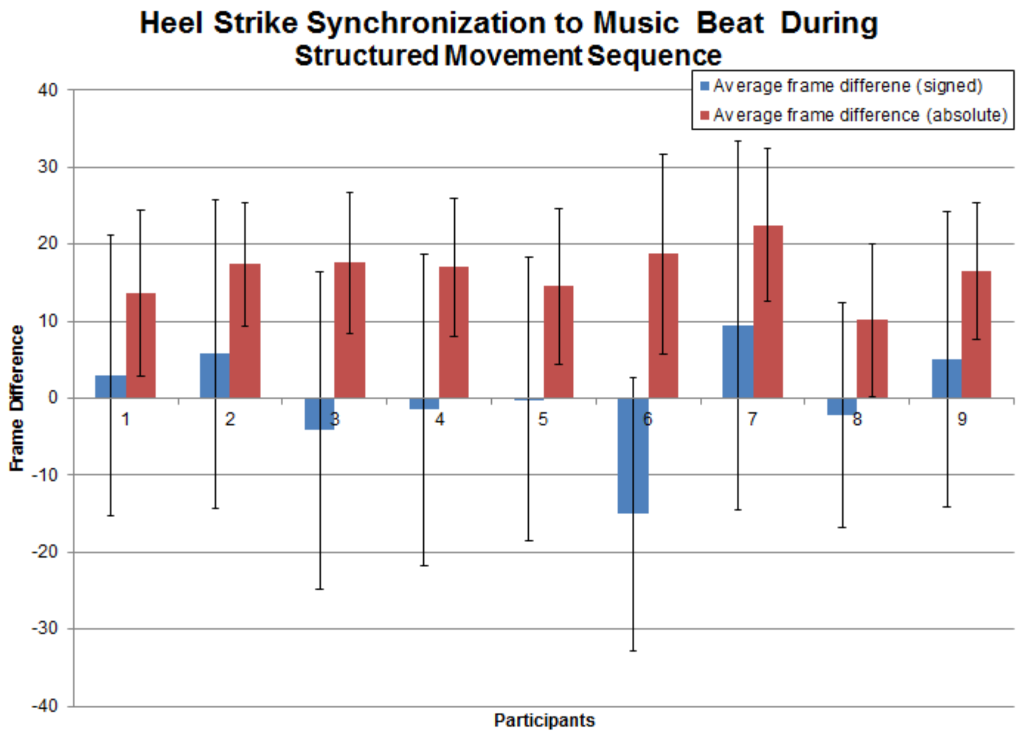

Figure 12: Average frame difference (signed and absolute) between heel strike and closest music beat with standard deviation error bars for the music condition during the structured movement sequence portion of the movement task for all participants. For the signed (blue) measures, a positive value means that the heel strike occurred after the closest music beat frame, whereas a negative value means that the heel strike occurred before the closest music beat frame. For the absolute (red) measures, a smaller value means that, whether it was before or after, the heel strike was more synchronized with the closest music beat frame.

For the standard deviation of the signed frame difference (blue bars), participant 8 had the lowest level of variation and participant 7 had the highest level of variation. For the absolute measures (red bars), representing closeness to the music beat, participant 8 (largest anxiety change) had the lowest average difference, indicating good synchronization with the closest music beat. Participant 7 had the highest average difference (absolute).

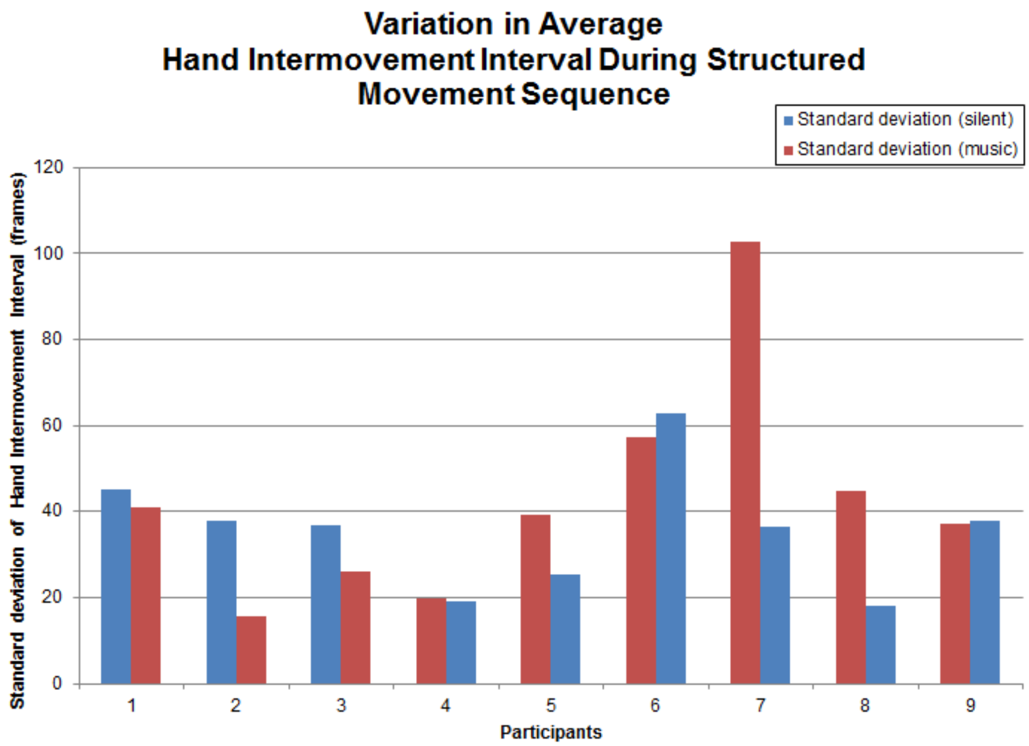

Figure 13: Standard deviation of intermovement (frame difference between each of the 8 selected hand movement frames) for the averaged hand for both conditions (silent and music) during the structured movement sequence portion for all participants. Colors of the bars indicate the testing condition (blue for silent, red for music) and order of bars for each participant indicate the order of testing. For the univariate ANOVA, no significant differences were found between the music 1st and music 2nd group as well as music or silent condition.

Considering the standard deviation bars as a measure of movement consistency, on average when looking at the entire group of participants, movement with music did not necessarily result in less variability. For the music 2nd group, there was less variability, on average, when music was added; whereas for the music 1st group, there was more variability in the music condition. For the music condition, differences between the average interstep and occurrence of the music beat will be looked at below. Participant 8 had the least variability (lowest standard deviation) for the silent condition.

In the movement data with music, what is relationship between the hand movement of the participant (during the walking and/or structured movement sequence) to the beat of the music, either on, just before, or just after?

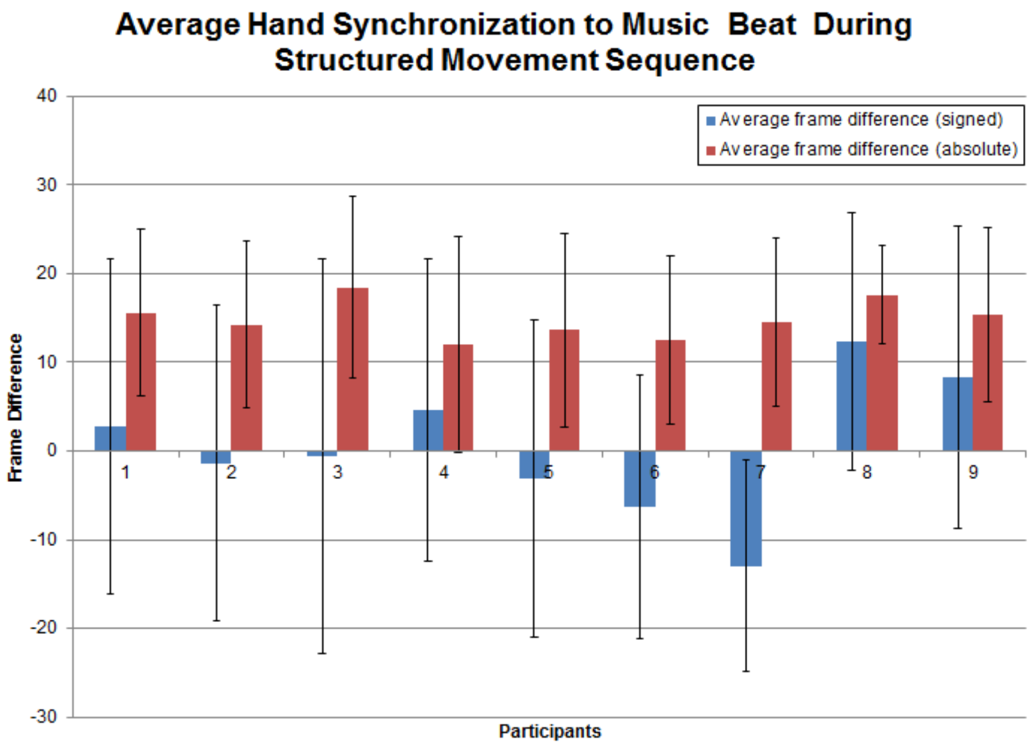

Figure 14: Average frame difference (signed and absolute) between frames of the 8 selected average (left combined with right) hand movement frames and the closest music beat frame with standard deviation error bars for the music condition during the structured movement sequence portion for all participants. For the signed (blue) measures, a positive value means that the selected hand movement frame occurred after the closest music beat frame, whereas a negative value means that the selected hand movement frame occurred before the closest music beat frame. For the absolute (red) measures, a smaller value means that, whether it was before or after, the hand movement was more synchronized with the closest music beat.

For the standard deviation of the signed frame difference (blue bars), Participant 7 had the lowest level of variation and Participant 3 had the highest level of variation. For the absolute measures (red bars), representing closeness to the music beat, Participants 4 and 6 (largest anxiety change) had the lowest average difference, indicating good synchronization with the closest music beat. Participants 3 and 8 had the highest average difference (absolute).

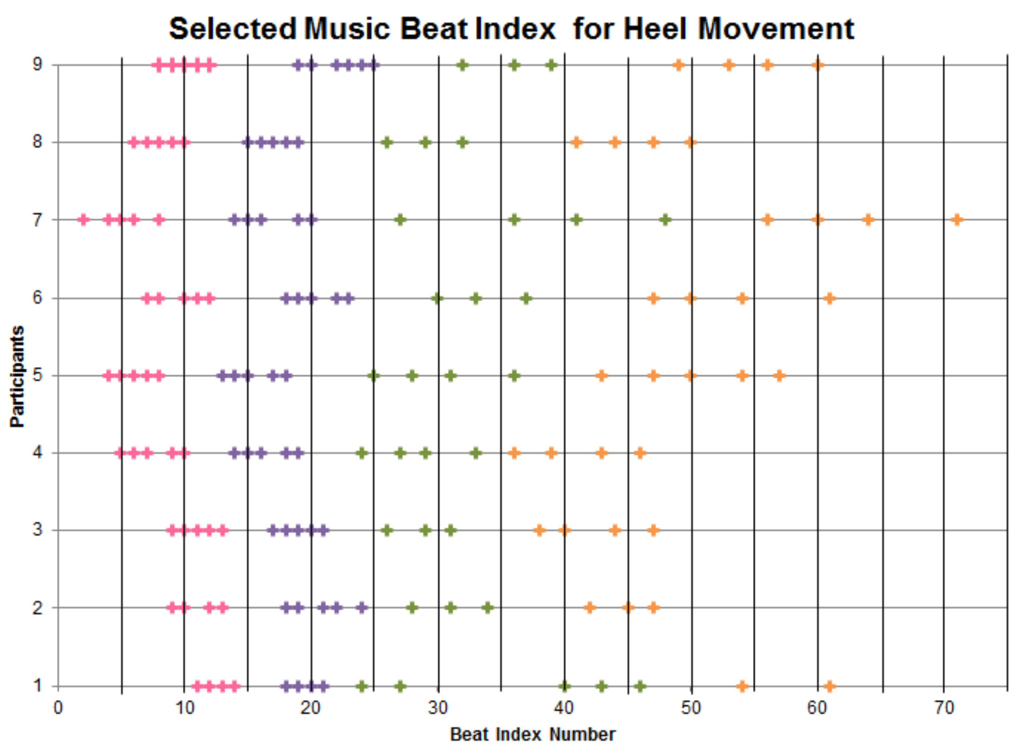

Figure 15: Graph of selected music beats for each participant for heel movement during movement task. For every heel strike, the music beat closest in time was selected. Pink dots are during the first half of the walking portion, purple dots are during the second half of the walking portion, green dots are during the first half of the structured movement sequence, orange dots are during the second half of the structured movement sequence.

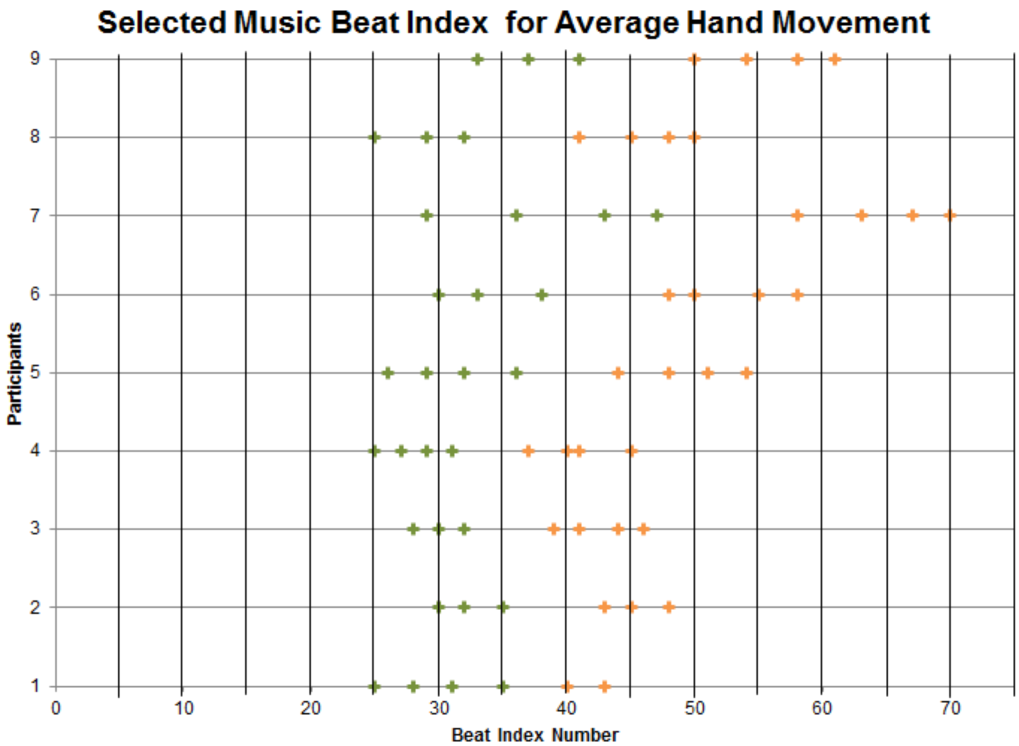

Figure 16: Graph of selected music beats for each participant for averaged (average time for when the two hands stopped at each selected movement) hand movement during movement task. For every selected hand movement, the music beat closest in time was selected. Green dots are during the first half of the structured movement sequence, orange dots are during the second half of the structured movement sequence.

Part III: Is there an interaction effect between how much anxiety levels changed and degree of rhythm change in participants when comparing the two testing sessions? Is there any relation between having good "rhythm" and level of anxiety?

Ignoring the order of conditions and learning effect, the difference in STAI scores and rhythm between music and silent conditions were analyzed to see how much music affected anxiety and movement/rhythm. For each participant, to see the anxiety affect, the pre-post STAI difference for both silent and music conditions were first made, then the difference of these two scores (music-silent) was taken. A positive result would mean that there was a larger reduction in anxiety in the music condition than there was in the silent condition. To see the rhythm effect, the difference between standard deviations in the movement interstep between sessions (music-silent) for the heel kinematic data during the walking portion, the heel kinematic data during the structured movement sequence, and the averaged hand kinematic data during the structured movement sequence was calculated. A negative value meant that the silent condition had a larger standard deviation and there was less movement variation and more rhythm during the music session.

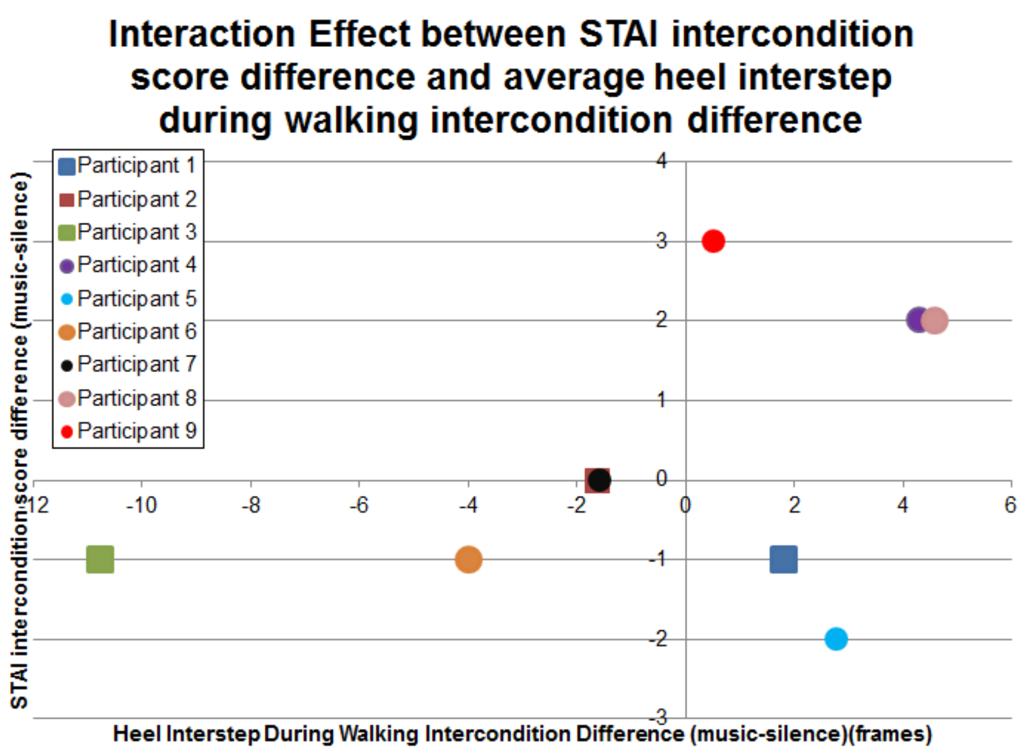

Figure 17: Shows interaction effects between STAI intercondition (music minus silence) score difference (pre minus post) and average heel interstep during walking's standard deviation intercondition difference (music minus silence) for all subjects.

Because individual variation is so high in these interaction graphs, only data from Participants 5, 8, and 9 (participants previously highlighted for largest anxiety change) were analyzed. Because they had a positive value on the y-axis, Participants 8 and 9 had a larger anxiety reduction in the music condition than the silent condition. Because these two participants had a positive value on the x-axis, there was more movement variation and less rhythm during the music condition. This could be because both of these participants are part of the music 1st group. Music reduced their anxiety, but also reduced their rhythm. The latter could be because of the learning effect. Participant 5, another profile subject, had a smaller anxiety reduction and rhythm decrease in the music condition than the silent condition.

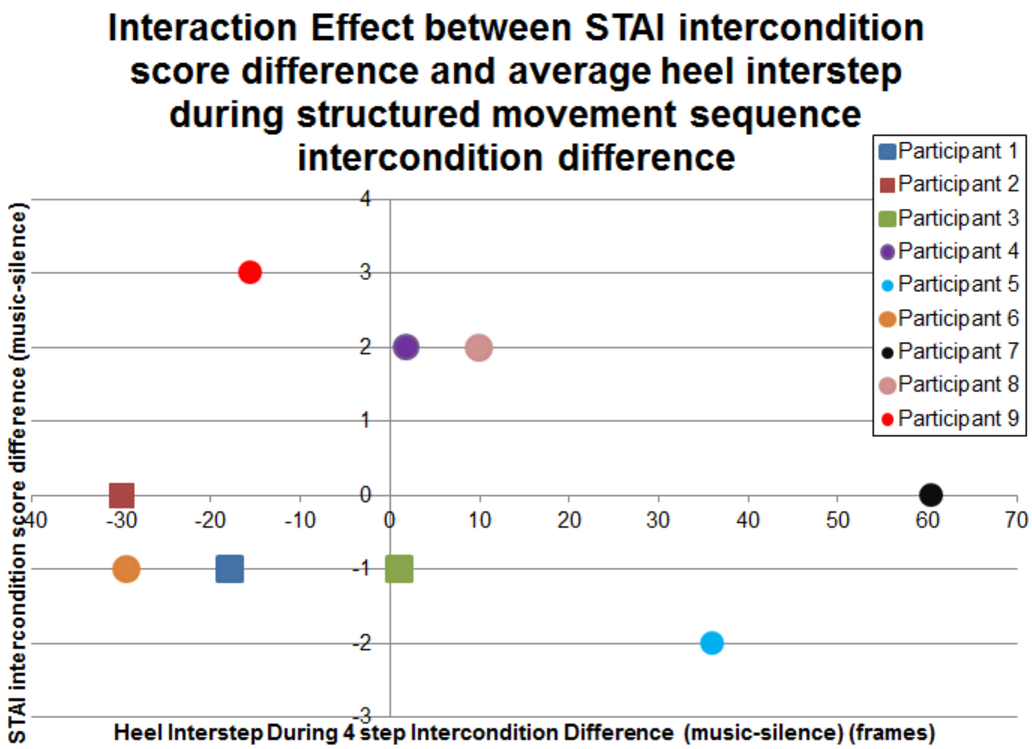

Figure 18: Shows interaction effect between STAI intercondition (music minus silence) score difference (pre minus post) and average heel interstep during structured movement sequence the standard deviation intercondition difference (music minus silence) for all subjects.

Because they had a positive value on the y axis, Participants 8 and 9 had a larger anxiety reduction in the music condition than the silent condition. Because the movement changed and became more complicated (from walking to structured movement sequence), these two participants shift over to the left on the x-axis, thus showing higher rhythm during the music condition than the silent condition. Participant 5, still with the smaller anxiety reduction in the music condition than the silent condition, when the movement became more complicated, had more movement variation in the music condition.

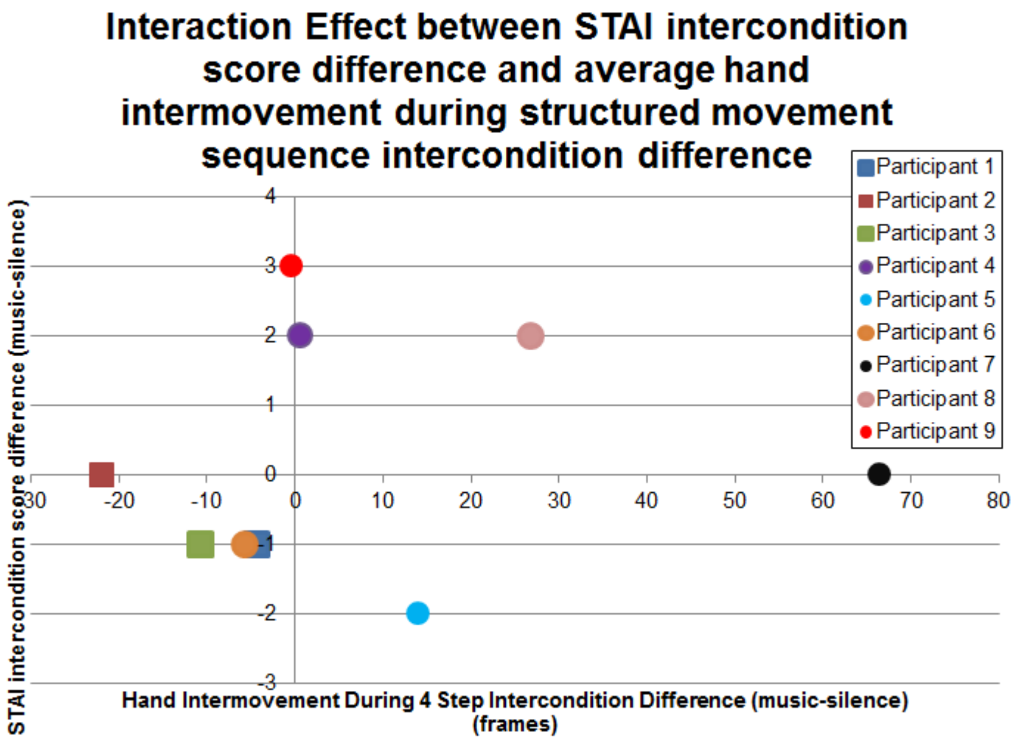

Figure 19: Shows interaction effect between STAI intercondition (music minus silence) score difference (pre minus post) and average hand intermovement during structured movement sequence standard deviation intercondition difference (music minus silence) for all subjects.

Because they had a positive value on the y-axis, Participants 8 and 9 had a larger anxiety reduction in the music condition than the silent condition. Because the movement changed and became more complicated (from walking to structured movement sequence), and recognizing this is measuring the hand instead of heel movement, these two participants shift over to on the x-axis to be between where they were for the previous two graphs. Participant 5, like the heel data, still had more movement variation in the music condition.

Discussion

Movement had an effect on anxiety for Participants 5, 8, and 9

As seen in Figure 3, because their STAI score differences were greater than 1, Participants 5, 8, and 9 showed that the movement task in this study had an effect on their anxiety. For their individual anxiety changes seen during the music condition sessions, their questionnaire results in item A1 of Appendix A can be examined to see if they were actively listening to the music. In response to the question “How were you focusing or paying attention to the music?”, Participant 5 was “subconsciously maybe”, Participant 8 was “using the beat to break the sequence into components”, and Participant 9 was going “by the beat, and a little bit of the melody and the bass line”. Participant 8 and 9’s higher level of self-reported interaction with the music could help explain why their anxiety reduced more during the music condition.

Effects of music on rhythm of movement

As seen in Figure 9 (standard deviation of heels during walking), the music bar (red) was higher for Participants 5, 8, and 9, indicating less synchronization with the music beat. For the entire subject group, movement with music was not necessarily more synchronized with the music beat. For the music 2nd group, there was more synchronization with the music beat when music was added (lower standard deviation). For the music 1st group, there was less synchronization with the music beat during the music condition (higher standard deviation). This could support the practice effect of the study. In Figure 10 (standard deviation of heels during the sequence 4 step), when comparing movement with music versus movement without music, Participant 5 had less synchronization with the music beat, whereas Participants 8 and 9 had more synchronization. Similar to the walking portion, when comparing movement with music versus movement without music, the entire group had less synchronization with music beat, the music 2nd group had more synchronization with the music beat, and the music 1st group had less synchronization with the music beat. In Figure 11 (standard deviation of hands during 4 step), when comparing movement with music versus movement without music, Participants 5 and 8 had less synchronization with the music beat, whereas Participant 9 had more synchronization. Like the heel data, when comparing movement with music versus movement without music, the entire group had less synchronization with music beat, the music 2nd group had more synchronization with the music beat, and the music 1st group had less synchronization with the music beat.

The effect of music when added to movement on anxiety for Participants 5, 8, and 9

The Interaction Effect graphs (Figures 17-19) looked for any relation between having good "rhythm" and level of anxiety. Participants 8 and 9 had a larger anxiety reduction in the music condition than the silent condition. Participant 5, another profile subject, had a smaller anxiety reduction in the music condition than the silent condition. In Figure 17 (interaction graph of heel during walking), for Participants 8 and 9 there was more variation in movement during the music condition. This could be because both of these participants are part of the music 1st group. Music reduced their anxiety, but also increased their movement variation. The latter could be because of the learning effect. Participant 5 had more movement variation in the music condition than the silent condition. In Figure 18 (interaction graph of heel during the structured movement sequence), Participants 8 and 9 showed less variation during the 4 step than the walking (perhaps because movement changed and was novel and more complicated) when comparing the music to silent condition. Participant 5, when the movement became more complicated, had more movement variation in the music condition. In Figure 19 (interaction graph of hand during the structured movement sequence), Participants 5, 8 and 9 showed more movement variation compared to Figure 18 but less movement variation than in Figure 17.

The movement data between the music and silent conditions were compared to see if there was evidence of the effect of the music on the movement pattern. In Figure 9 (standard deviation of heels during walking) and Figure 10 (standard deviation of heels during the structured movement sequence), there was more regular timing in the movement during the music condition for all subjects. It should be noted that for the music 2nd group, for all three movement measures (heel during walking, heel during structured movement sequence, and hands during structured movement sequence), movement during music had much better consistency than movement without music. The opposite was seen for the music 1st group.

Next, it was studied whether, for movement data with music, there was a relationship in the movement of the participant (during the walking and/or structured movement sequence) to the beat of the music, either on, just before, or just after. In Figure 11 (heel strike synchronization to music beat during walking), Participants 5 and 9 were after the music beat whereas Participant 8 was before the music beat. In Figure 12 (heel strike synchronization to music beat during the structured movement sequence), Participants 5 and 8 were just barely before the music beat and Participant

9 was after the beat. In Figure 16 (average hand synchronization to music beat during the structured movement sequence), Participant 5 was just before the beat whereas Participants 8 and 9 were after it.

The significance of the testing order in movement variation

Music did make a difference in the participants' movement patterns, but that difference seemed to depend on their familiarity with learning the movement task. This practice effect was explored for the highlighted Participants 5, 8, and 9, who were in music 1st group. In Figure 9 (standard deviation of heels during walking), the standard deviation for the music condition was higher than that of the silent condition for all three participants. In Figure 10 (standard deviation of heels during the structured movement sequence), the standard deviation for the music condition was higher for Participant 5 but much lower than that of the silent condition for Participants 8 and 9. In Figure 11 (standard deviation of hands during the structured movement sequence), the standard deviation for the music condition was higher for Participants 5 and 8 but much lower than that of the silent condition for Participant 9.

Depending on the order of conditions, the walking portion of the movement task could cater more to non-dancers to just naturally feel the beat whereas the structured movement sequence could cater more to the participants with some dance experience who are more comfortable with learning the choreography and could focus on the music.

Overall, the lower variability/higher rhythm in the silent condition data was seen in the music 1st group whereas the lower variability in the music condition was seen in the music 2nd group. This supports the learning effect. This can be seen in the feedback questionnaire (Appendix A), during the silent condition when asked if the movement task was difficult to learn, the music 2nd group (silent condition being their first session) reported having some difficulty whereas the music 1st group (silent condition being their second session) all reported to have no trouble in learning/performing the task. Vice versa was seen for the questionnaire answers during the music condition.

Other notable points

To help justify the protocol decision to only look at the heel and hand body markers for analysis, it was studied whether the heel movements were more or less sensitive than hand movement when trying to match with the music beat. This was observed in Participant 8 who, during the music condition, had a much higher level of synchronization with the beat of the music in the heels than hands. For the music condition questionnaire results (Appendix A), Participant 8 was the only participant to say that they were focusing on the individual left and right feet movement as well as actively listening to the song by using the beat of the music to break the sequence into components. Conversely, Participant 7 had a higher level of synchronization with the beat of the music in the hands and not the heels. Thus, it seems that the answer varies per tested individual. For the silent condition questionnaire results, Participants 6 and 7 were the only participants to report that they were thinking about their hand movement during the structured movement sequence. For the music condition questionnaire results, Participant 7 said they were “focused on remembering footsteps and trying to move hands at the same time” during the structured movement sequence.

Some differences were found in the data between the music and silent condition, but since there was such a high level of variation, more research needs to be done to determine if movement during music changes because listening to music causes relaxation or because a person is intentionally trying to move with the music. This level of variation could be potentially reduced by taking measures such as having a larger sample size, being more detailed in subject screening for having a background in music and dance, and increasing the length of the movement task. When looking at the feedback questionnaires (Item A1 in Appendix A), none of the participants had heard the song before, participants would find the movement task slightly difficult to learn during their first session but not difficult to recall at all during their second session, and all participants reported that they listened to music while doing other daily activities.

Participants in the music 2nd group could have come up with a song internally during their first session (silent) to move in accordance with. Conversely, during their second session (silent), participants in the music 1st group may have subconsciously or consciously replayed the song (which they were exposed to in their first session) while doing the movement task. These two features could have influenced the observed movement patterns.

During the music condition, the standard deviation of movement was higher for the music 2nd group for the heel and hand movement during the structured movement sequence. The standard deviation of movement was higher for the music 1st group for the heel movement during the walking portion. Thus, despite them having the advantage of getting a silent practice session before being tested with the music, adding music did not seem to help reduce variation in movement for the music 2nd group during the structured movement sequence, but did during the walking portion.

Another point of discussion is if the practice effect (score difference between 1st and 2nd testing session) is stronger than the music effect (score difference between music and silent condition) when it comes to reducing anxiety. Perhaps having music playing during the movement for their first session made the music 1st group feel more relaxed and comfortable about the movement task. Furthermore, since their first exposure to being tested with the movement task involved it being coupled with a particular song, it is possible that the music 1st group was playing the song in their head during their second testing session (silent). This could explain why more anxiety reduction was seen in the music 1st group (Figure 3). However, for the highlighted subjects, Participant 5 seemed to be affected more by the practice effect than the music effect, since their second session (silent) reduced their anxiety and their first session (music) did not (Figure 3).

Conclusion

The findings and protocol of this experiment can be compared to other related studies. Whereas Urakawa 2005 had subjects either listen to music or silence during the pre and post exercise rest periods, this experiment had the music intervention take place during the movement task. Urakawa 2005 also allowed participants to bring their own music to listen to and the exercise was pedaling on a cycle ergometer for 15 minutes, which is a longer and more aerobically intensive exercise. Jia et al. also utilized self-selected music but had participants listen to it while exercising on a cycle ergometer instead of during the rest periods. Both of these studies measured heart rate frequency to assess autonomic nervous system activity. While Han et al. did not have any kind of movement or exercise task, they utilized similar anxiety measurements as this experiment (STAI, heart rate, and oxygen saturation). Having participants lie down and listen to 30 minutes of self-selected music, they found a decrease in physiological stress response (heart rate) in the group that listened to music and an increase in heart rate for the group that sat in silence without music for 30 minutes. Only participants in the music listening group had a significant reduction in anxiety on the STAI.

Several aspects of this experiment could be changed to improve and simplify the results. It is likely that participants had higher anxiety for their first session compared to their second, regardless of the conditions. The time of day for testing varied per individual as well as what the participant had going on (e.g., being tested while nervous for evening exam to be taken right after, in the morning at 7:30am before going to work, in the late evening at 8pm after a long day of work) but most of the participants, while familiar with UT campus, had not been to the specific testing location nor done an experiment like this before. One participant had clear anxiety during their first session due to not wearing proper athletic attire and feeling uncomfortable for not having carefully read the confirmation email that provided a description of how the session would be. To help address this, the session confirmation email could be revised to be an online learning module where the participant would have to read and click to confirm that they have read statements explaining how the session would be conducted, what to wear, etc. as well as watch a video of a first person perspective of someone walking from the parking spot, into the building, up the elevator, and to the lab. This would help lessen some of the extra anxiety participants would face for that first session.

As mentioned prior, making the movement task longer could help address the issue of individual variation. This protocol change would also likely change the results of the 3 anxiety measures. Another aspect of this study that could be altered would be adding a separate subject group that, instead of completing the movement task, would sit in silence or sit and listen passively to the music. This would control for the effect that music alone has on anxiety. Participants could also be required to listen to music passively for at least 1 hour to help control how much music they listen to. Because personal preference has a strong impact on a person's response to music, allowing participants to select the music piece could also affect the results.

This experiment associated synchronization to the music with the music beat, which is commonly thought of as the most prominent rhythmic component of a music piece. However, the participants could have been focusing their movements on other parts of the song which were not highlighted, such as rhythmic density, rhythmic complexity, and auditory cues. Entrainment of the human body to music is incredibly complex, as it can range from simple finger tapping to full-body dancing. Even within full-body dancing, which this study looked at, humans can express their induced movement through different kinds of movement, such as swaying side to side, period-locked movement, as well as using different parts of their body being synchronized to different parts of the music (Burger, Thompson, Luck, Saarikallio, & Toiviainen, 2014). While the movement task in this experiment was neither dance nor exercise, but instead a general rhythmic movement, the protocol and findings from this study could be used for an experiment looking at the effects of dance on anxiety (Lest & Rust, 1990).

This study was successful at capturing data and identifying certain movement patterns as well as measuring anxiety changes. While a research perspective of this experiment would prioritize the outcomes of the specific hypotheses, the high level of individual variation observed in the data is of high importance in clinical and educational settings, as they may guide clinicians, teachers, and coaches to modify their instruction. A practice effect was also seen among the participants. It was thought that the music 2nd group would have less variation in movement and closer synchronization to the music beat since they were allowed to practice the movement task without the distraction of the music during their first session (silence) to focus on the specific movements. This technique of verbal instruction, then running through the choreography without music, then running the choreography with music is used in most dance classes. However, in this study, the largest anxiety change was seen in the music 1st group. How both the observed practice effect and reduction in anxiety were found in tested individuals when music accompanied the music needs to be further explored.

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Biography

Michelle Dunn grew up in The Woodlands, a northern suburb of Houston, Texas. Upon graduating high school, she enrolled in the Plan II Honors program and Neuroscience program at the University of Texas at Austin. During her time at the University, she became involved with on campus research, aerials, and pre-med organizations. After graduating from both degrees in May 2017, she plans to pursue a career in clinical research while applying to graduate programs.

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Appendix A – STAI Data

Appendix A1: Post-movement task questionnaire responses

Post-STAI Interview Questions
Date:
Session: Silence
Participant:

During the walking portion of the movement task, what were you mainly focusing on?

1. Reaching the x mark and the portions involving blue tape
2. Getting to the ‘x’’s on the floor
3. Where to put my feet
4. Poster straight ahead during start, scale on way back
5. On my steps
6. Following the path to the x’s
7. Focused on my feet; walking steadily
8. The x’s ahead of me
9. Walk straight, all the HW I need to do

During the movement sequence portion, what were you mainly focusing on?

1. The turning
2. Remembering the movements
3. The order of the movements, where to put my feet
4. Completing movements in correct order
5. Since there was no music, I came up with a count in my head
6. Doing the hand movements
7. Focused on moving hands in coordination with my feet
8. Each separate movement via L/R foot
9. Getting the sequence right

Was the movement sequence portion difficult to learn and remember?

1. Somewhat. Most difficult aspect was the turning (more specifically remembering the orientations with respect to the walls)
2. No, it was not difficult to learn or remember
3. Not really, but I did mess up a movement so…
4. Easy to remember and took a little more effort to learn
5. Not at all
6. No
7. No- it was easy to remember today
8. No
9. no

Post-STAI Interview Questions

Date:
Session: Music
Participant:

During the walking portion of the movement task, what were you mainly focusing on?
1. Where to put my feet
2. Going to the x mark and blue tape
3. Nothing
4. Getting to the other side. Walking towards a picture on the wall
5. On running the sequence through my mind and beats
6. Walking to the x's
7. Focused on not crossing hands, turning at the white x
8. The x or blue tape I was walking to
9. The song beat/tempo

During the movement sequence portion, what were you mainly focusing on?
1. The turning portions
2. Listening to the music
3. Balancing and which movement was next
4. Making sure movements correct. Such as recalling R step arms up
5. Getting the sequence right
6. Getting the motions right
7. Focused on remembering footsteps and trying to move hands at the same time
8. Left and right feet movement
9. Getting the sequence right

How were you focusing or paying attention to the music?
1. Using it to set my motions
2. Just listening to it
3. I listened to the beat and melody; it might have actually interfered with the movements because I both wanted to step to the music and not change how I moved, so I was conflicted
4. Very little
5. Subconsciously maybe
6. I wasn't paying attention to the music
7. I was listening to it in the background
8. Using the beat to break the sequence into components
9. By the beat, and a little bit of the melody and the bass line

Was the movement sequence portion difficult to learn and remember?
1. The direction to turn in
2. No
3. Not really, especially after doing it two days in a row
4. Slightly difficult to learn, somewhat easy to remember

5. No
6. No
7. Yes
8. Not too bad
9. no

Did you recognize the music being played?

1. No
2. No
3. No
4. No
5. No
6. No
7. No
8. No
9. no

What genre of music do you prefer to listen to on your own? You can list several types if more than one.

1. Anything, as long as it's not country
2. Electric, hip-hop, swing
3. Indie, alternative, classical
4. Country, rock, alternative
5. Soft rock
6. Hip/hop, reggae
7. Alternative, top 40
8. Mostly country
9. Opera, pop, orchestral, soft rock, edm/dance, piano

Is exercise and/or physical activity part of your regular schedule? If yes, how often do you listen to music when partaking in these activities?

1. Yes. I don't listen to music while exercising
2. Yes, most of the time
3. Yes; I listen to music during about half of those activities
4. Workout 4 days a week and active for at least 4 hours during the week, not on weekends. Listen to music sometimes when working out; 50% of time
5. Yes. Only while working out or running
6. Yes. ~75% of the time I use music
7. No
8. Yes, and always
9. Yes, and I always listen to music

Do you listen to music while doing other activities (e.g. reading, studying, and driving)? If so what kind and which activities?

1. Yes. Reading, studying, driving
2. Yes, cleaning, driving, anything creative (i.e. writing, drawing, etc.)
3. Yes; driving, studying
4. Studying- compositions and film scores; driving- country or rock
5. Driving
6. Yes, driving, walking, chilling
7. Yes- driving, responding to emails; I cannot listen to music while reading
8. I do listen to music when I am driving. I listen to movies while studying or doing housework or reading.
9. Yes. Driving, studying, reading, getting between classes. Sometimes it helps w/ falling asleep or starting the day. Also in the shower and while I do chores.

Appendix A2: Pre-movement questionnaire sample scoring sheet

Pre-STAI

Date:
Session:
Participant:

State-Trait Anxiety Inventory (STAI)
Self-evaluation questionnaire (Y-6 item)

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the most appropriate number to the right of the statement to indicate how you feel ***right now, at this moment.***
There are no right or wrong answers. Do not spend too much time on any one statement, but give the answer which seems to describe your present feelings best.

	Not at all	Somewhat	Moderately	Very much	SCORE
1. I feel calm	1	2	3	4	1. 4
2. I am tense	1	2	3	4	2. 2
3. I feel upset	1	2	3	4	3. 3
4. I am relaxed	1	2	3	4	4. 3
5. I feel content	1	2	3	4	5. 2
6. I am worried	1	2	3	4	6. 4

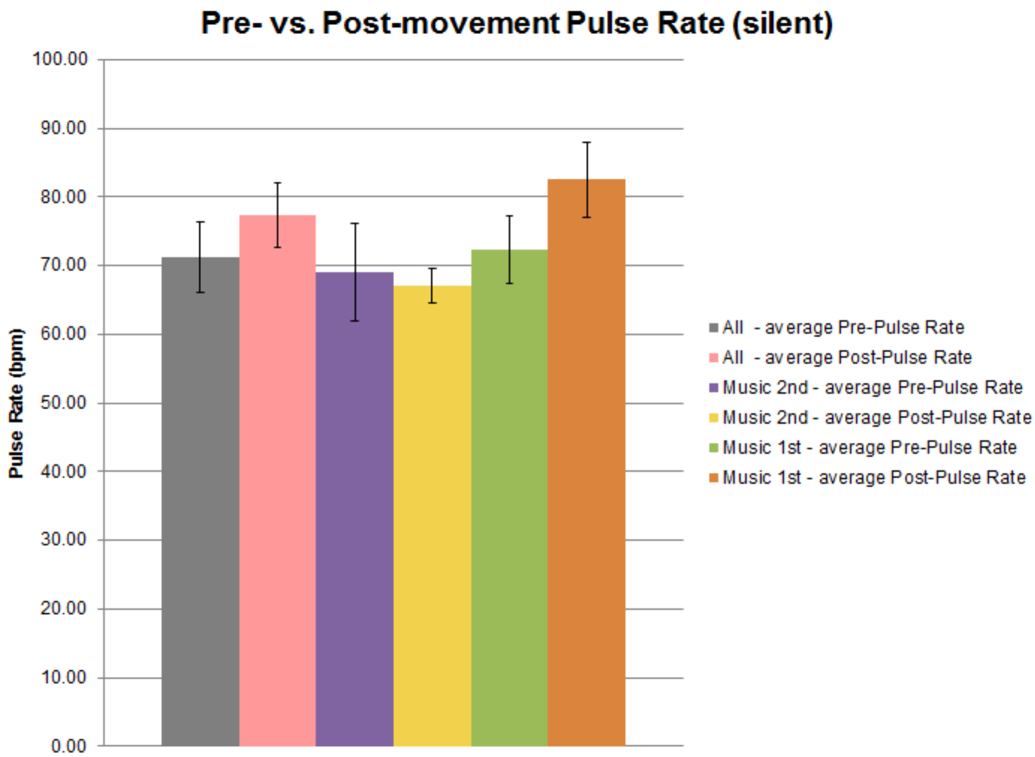
Anxiety present
Anxiety absent

Please make sure that you have answered *all* the questions.

Item A2: An example of a completed STAI questionnaire that all participants were given before and after completing the movement task for both sessions. Scoring was done by first separating the anxiety present statements from the anxiety absent statements (highlighted in red and blue below). For anxiety absent statements, the ranked number scale was reversed, making the score for "not at all" be 4 instead of 1, "somewhat" being 3 instead of 2 and so on. This aligns with how a higher total score indicates a higher anxiety level. Then the revised scores for each statement were summed together.

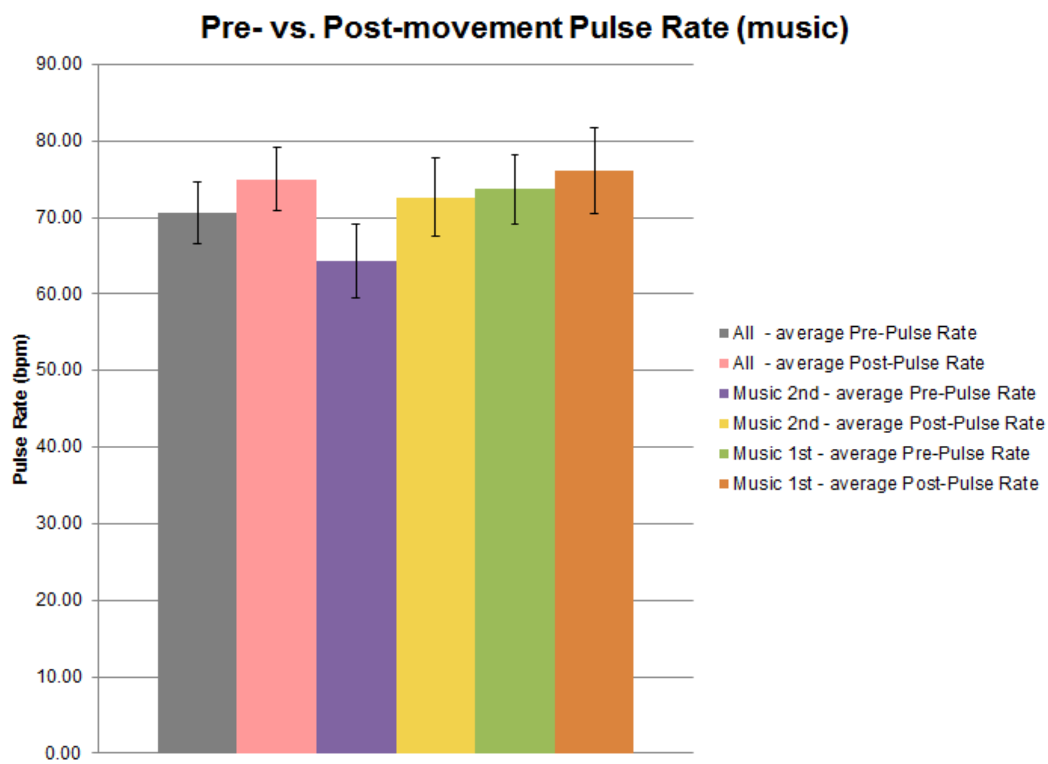
Appendix B – Pulse Rate Data

Appendix B1



Item B1: Average pre- and post-movement task pulse rate values for all participants, participants in the music 2nd group, and participants in the music 1st group during the silent condition. Bars are standard error. Music second means that their first session was silent and second session was music. Vice versa for music first.

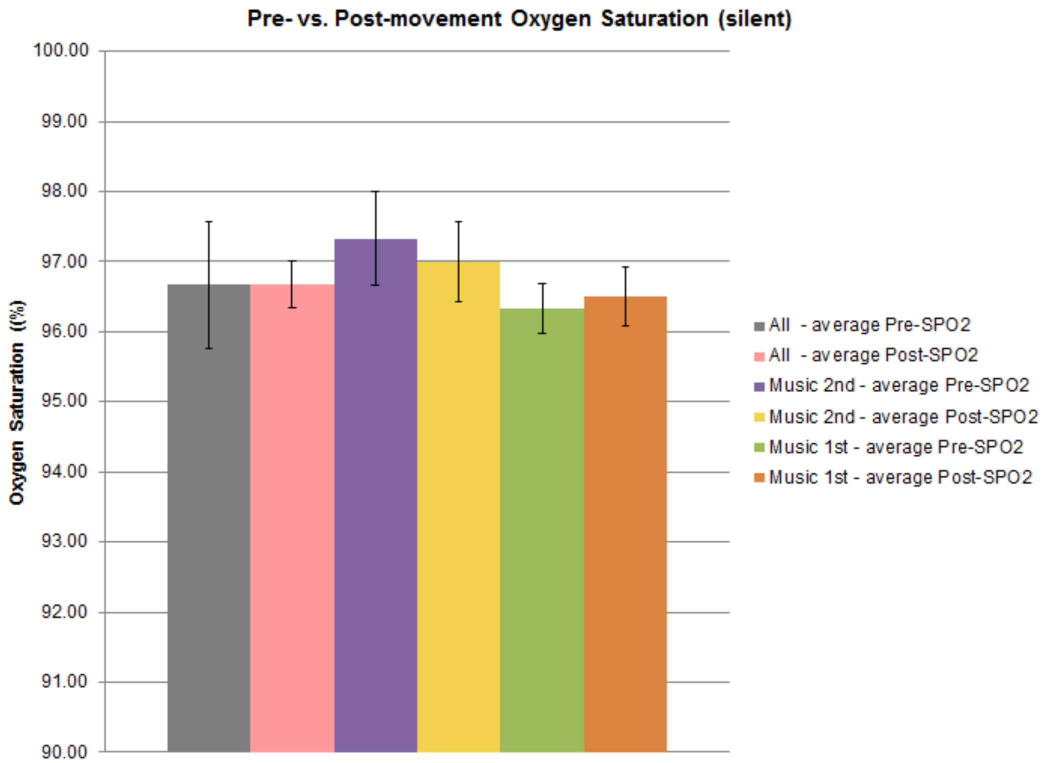
Appendix B2



Item B2: Average pre- and post-movement task pulse rate values for all participants, participants in the music 2nd group, and participants in the music 1st group during the music condition. Bars are standard error. Music second means that their first session was silent and second session was music. Vice versa for music first.

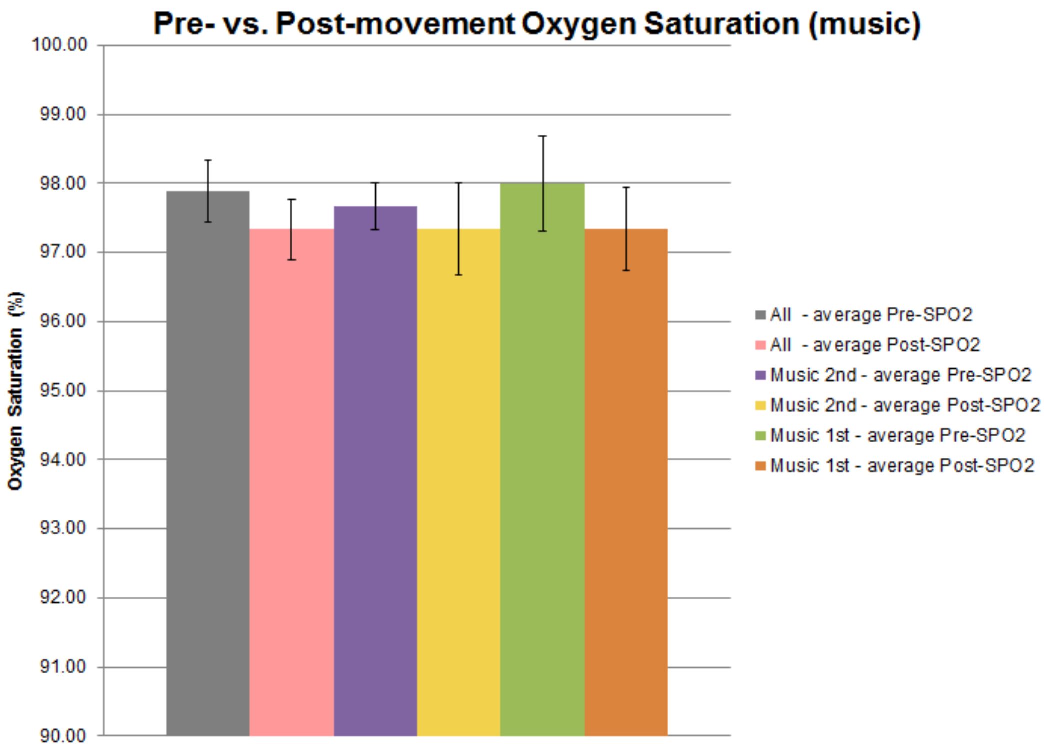
Appendix C – Oxygen Saturation Data

Appendix C1



Item C1: Average pre- and post-movement task oxygen saturation values for all participants, participants in the music 2nd group, and participants in the music 1st group during the silent condition. Bars are standard error. Music second means that their first session was silent and second session was music. Vice versa for music first.

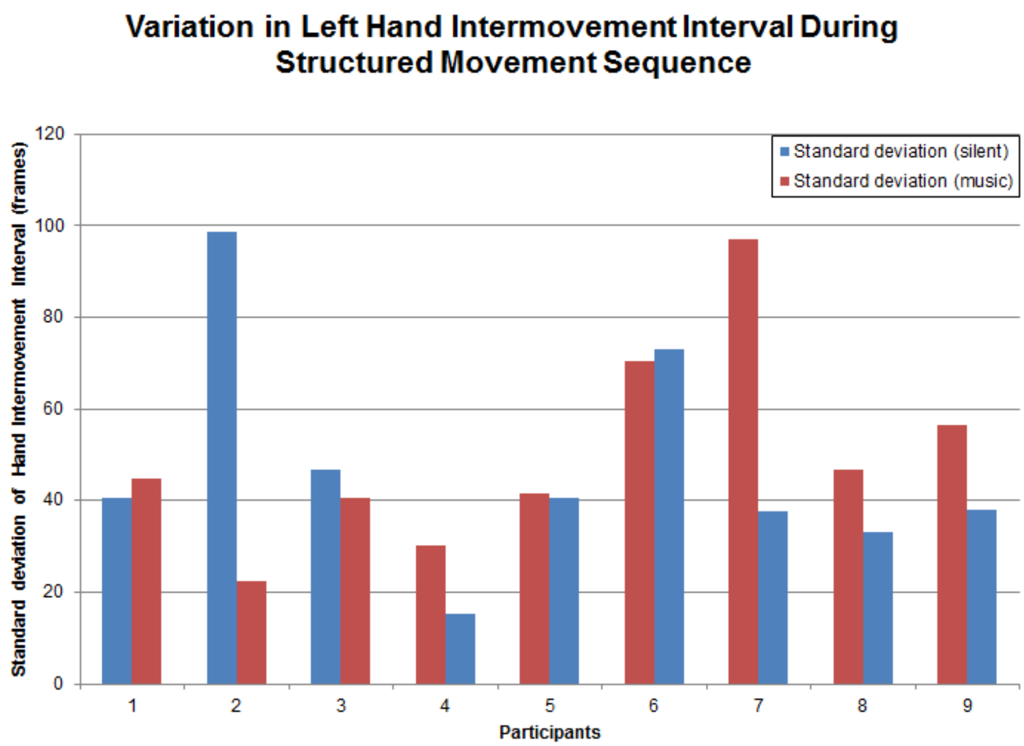
Appendix C2



Item C2: Average pre- and post-movement task oxygen saturation values for all participants, participants in the music 2nd group, and participants in the music 1st group during the music condition. Bars are standard error. Music second means that their first session was silent and second session was music. Vice versa for music first.

Appendix D – Hand Movement Data

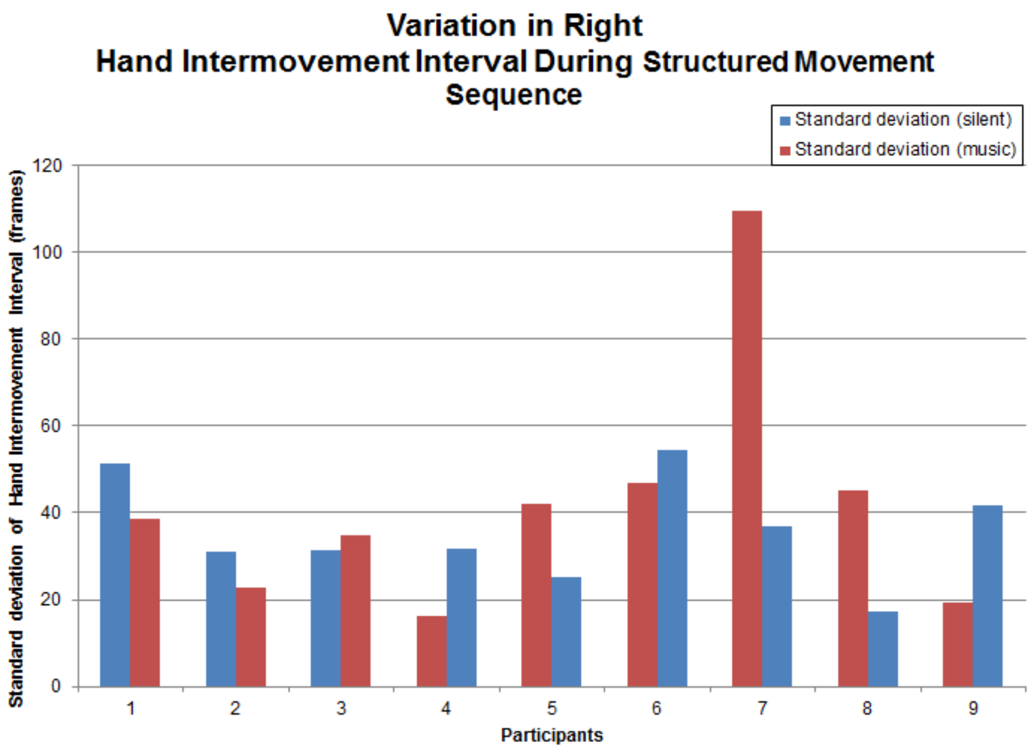
Appendix D1



Item D1: Standard deviation of intermovement (frame difference between each of the 8 selected hand movement frame) for the left hand for both conditions during the structured movement sequence portion of the movement task for all participants. Colors of the bars indicate the testing condition (blue for silent, red for music) and order of bars for each participant indicate the order of testing.

Considering the standard deviation bars as a measure of movement consistency, on average, movement with music did not necessarily result in less variability, when looking at the entire group of participants. For the music 2nd group, there was less variability, on average, when music was added, whereas for the music 1st group, there was more variability in the music condition. Participant 8 had the second least variability with the lowest standard deviation for the silent condition.

Appendix D2



Item D2: Standard deviation of intermovement (frame difference between each of the 8 selected hand movement frame) for the right hand for both conditions during the structured movement sequence portion of the movement task for all participants. Colors of the bars indicate the testing condition (blue for silent, red for music) and order of bars for each participant indicate the order of testing.

Considering the standard deviation bars as a measure of movement consistency, on average, movement with music did not necessarily result in less variability, when looking at the entire group of participants. For the music 2nd group, there was less variability, on average, when music was added, whereas for the music 1st group, there was more variability in the music condition. Participant 8 had the least variability with the lowest standard deviation for the silent condition. Participant 5 had the second least variability for the silent condition. Participant 9 had the second least variability for the music condition.

Appendix E – Raw data table

Participant:	1	2	3	4	5	6	7	8	9	Total Average
Average Heel Walking Interstep Interval	69.17	83.33	73.14	74.50	72.71	80.63	75.11	66.88	72.88	74.26
Standard Deviation of Heel Walking Interstep Interval	4.83	19.36	23.07	2.88	2.06	12.85	21.40	4.91	3.72	10.56
Average Heel Structured Movement Sequence Interstep Interval	229.83	232.33	161.83	130.40	148.67	269.00	255.00	217.80	265.20	212.23
Standard Deviation of Heel Structured Movement Sequence Interstep Interval	41.58	45.33	30.89	42.43	16.31	103.47	49.64	40.49	33.00	44.79
Average of Left Hand Structured Movement Sequence Intermovement	228.00	177.17	140.83	151.17	128.50	251.67	215.67	168.20	238.67	188.87
Standard Deviation of Left Hand Structured Movement Sequence Intermovement	40.44	98.82	46.59	15.18	40.68	72.92	37.68	33.05	37.91	47.03
Average of Right Hand Structured Movement Sequence Intermovement	235.67	227.83	147.83	147.67	130.00	244.00	211.00	181.00	235.67	195.63
Standard Deviation of Right Hand Structured Movement Sequence Intermovement	51.21	30.87	31.25	31.66	25.06	54.47	36.90	17.24	41.81	35.61
Average Hand Structured Movement Sequence Intermovement	231.83	229.25	144.33	149.42	129.25	247.83	213.33	179.92	237.17	195.81
Standard Deviation of Average Hand Structured Movement Sequence Intermovement	45.26	37.79	36.93	19.13	25.35	62.93	36.45	18.04	37.71	35.51
Average Heel Walking Interstep Interval	64.33	86.71	72.00	77.50	68.38	76.38	79.75	67.88	77.22	74.46
Standard Deviation of Heel Walking Interstep Interval	6.65	17.75	12.29	7.19	4.84	8.85	19.83	9.51	4.24	10.13
Average Heel Structured Movement Sequence Interstep Interval	205.75	159.00	178.20	190.33	226.71	261.80	379.00	197.40	231.00	225.47
Standard Deviation of Heel Structured Movement Sequence Interstep Interval	23.70	15.43	31.93	44.34	52.39	74.09	110.13	15.84	17.52	42.82
Average of Left Hand Structured Movement Sequence Intermovement	209.33	151.50	138.83	160.83	210.50	231.00	306.67	191.50	209.50	201.07
Standard Deviation of Left Hand Structured Movement Sequence	44.78	22.53	40.53	30.35	41.56	70.32	97.01	46.78	56.51	50.04
Average of Right Hand Structured Movement Sequence Intermovement	211.00	161.33	157.50	142.75	211.33	208.67	309.67	191.33	224.17	201.97
Standard Deviation of Right Hand Structured Movement Sequence	38.76	22.73	34.86	16.07	41.95	46.78	109.76	45.06	19.36	41.70
Average Hand Structured Movement Sequence Intermovement	210.17	156.42	148.17	153.50	210.92	219.83	308.17	191.42	216.83	201.71
Standard Deviation of Average Hand Structured Movement Sequence	40.85	15.79	26.19	19.73	39.39	57.25	102.81	44.80	37.31	42.68
Average Heel Walking Movement to Music Beat Difference (signed)	-15.88	3.33	12.70	1.50	4.30	1.60	-6.10	-4.40	11.27	0.93
Standard Deviation of Heel Walking Movement to Music Beat Difference (signed)	9.23	17.66	25.84	19.82	20.76	18.55	23.36	12.76	26.96	19.44
Average Heel Walking Movement to Music Beat Difference (absolute)	15.88	14.44	20.30	16.10	17.10	14.60	19.50	10.40	22.18	16.72
Standard Deviation of Heel Walking Movement to Music Beat Difference (absolute)	9.23	9.46	19.73	10.35	11.25	10.49	12.83	8.00	18.03	12.15
Average Heel Structured Movement Sequence Movement to Music Beat Difference (signed)	3.00	5.80	-4.14	-1.50	-0.11	-15.00	9.50	-2.14	5.14	0.06
Standard Deviation of Heel Structured Movement Sequence Movement to Music Beat Difference (signed)	18.19	20.04	20.59	20.21	18.44	17.77	23.94	14.65	19.18	19.22
Average Heel Structured Movement Sequence Movement to Music Beat Difference (absolute)	13.67	17.40	17.57	17.00	14.56	18.71	22.50	10.14	16.57	16.46
Standard Deviation of Heel Structured Movement Sequence Movement to Music Beat Difference (absolute)	10.84	8.08	9.16	8.99	10.08	13.02	9.89	9.99	8.85	9.88
Average Hand Structured Movement Sequence Movement to Music Beat Difference (signed)	2.81	-1.38	-0.56	4.63	-3.13	-6.38	-12.94	12.38	8.25	0.41
Standard Deviation of Hand Structured Movement Sequence Movement to Music Beat Difference (signed)	18.88	17.85	22.20	16.99	17.92	14.86	11.89	14.50	17.04	16.90
Average Hand Structured Movement Sequence Movement to Music Beat Difference (absolute)	15.56	14.25	18.44	12.00	13.63	12.50	14.56	17.63	15.38	14.88
Standard Deviation of Hand Structured Movement Sequence Movement to Music Beat Difference (absolute)	9.42	9.42	10.23	12.19	10.96	9.42	9.51	5.51	9.89	9.62

Item E1: Table of movement averages and standard deviations for all participants for both conditions. Three right red columns are group averages (all, music 2nd, music 1st). Yellow highlight is smallest value, orange highlight is second smallest value, blue highlight is largest value, and green highlight is second largest

Research Proposal

1. Title
   Rhythm and Blues: The effect of music on movement patterns and anxiety

2. Principal Investigator
   Michelle Dunn, md26979, Department of Natural Sciences and Department of Kinesiology and Health Education
   Co-Investigators: Dr. Lawrence D. Abraham, lda1949, Dr. Jody Jensen, jljensen

3. Purpose
   The main purpose of this project is to find a more thorough method of quantifying the effects of music on movement patterns as well as the interactive effects of both on anxiety levels. This will serve to start bridging the gap between kinematic studies and creative art therapy studies, allowing for the sharing of research and knowledge between the communities of kinesiology, biomechanics, dance, psychology, neuroscience, and music. This project will examine both the effect that music has on movement patterns and anxiety as well as the relationship between movement patterns and anxiety if both factors are affected. It is expected that, compared to movement performance in silence, movement done while music with a pronounced beat is playing will show greater coincident rhythm. Furthermore, it is expected that anxiety levels, both reported and assessed physiologically, will decrease.

   Therapeutic approaches to reducing anxiety have recently included both music therapy and dance therapy. Anxiety is a mental condition that affects all populations, including those without a neurological mental illness. Although anxiety may be accompanied by stress, or even caused by stress, these two conditions are distinct. The fundamental reason stress is not the same as anxiety is that it is a state that may have physiological or cognitive causes. As such, a person may be stressed – as may happen during hard exercise - but not feel anxious. Finding an alternative route to confronting and coping with these issues instead of the more traditional medication or counseling may appeal to a larger or different group of people. In addition, incorporating a movement aspect to treatment of anxiety will add the benefits that physical exercise brings to health.

   Rhythmic Auditory Stimulation (RAS) is a treatment for gait rehabilitation that uses rhythmic cues either as metronome beats or metronome beats embedded in music, to direct gait parameters such as cadence, stride length, velocity, and symmetry. Motor benefits for patients with Parkinson's disease, cerebral palsy, Alzheimer's disease, and stroke have been found in both gait studies and modern Laban dance movement exercise programs using RAS. Yet only inconclusive results have been found for mood benefits. However, since RAS can incorporate music, and music is known to have a positive effect on mood, the music component of RAS should be further analyzed and enhanced with music therapy research to encourage mood benefit (Nombela, 2013). Certain aspects of music such as beats per minute, a pronounced beat, and anticipatory syncopation (back phrasing) can be manipulated to reduce anxiety by activating the mind of the listener and lifting their mood.

The State-Trait Anxiety Inventory (STAI) is a commonly used measure of anxiety in applied psychology research. It is a questionnaire that measures both state anxiety (how one feels at the moment) and trait anxiety (how one generally feels) with itemed questions alternating between anxiety-present and anxiety-absent. Shorter versions of the STAI are available for situations with time constraints (Marteau, 1992). This study will use a 6 item STAI instead of the full 40 item version because of the constraint of time and non-clinical population being tested.

This study will build on findings from several previous studies. One such study explored gait variability by manipulating the music of “Fur Elise” and looked at restoring nonlinear measures (fractal scaling of inter-stride interval gait variability) of gait by using RAS in young healthy adults. The researchers examined whether, when music was played, subjects’ walking would be synchronize so that their inter-stride interval of gait would be a multiple of the inter-beat interval of the piece, explaining why people unconsciously move to the beat of the music. The researchers performed trend analysis to see if there was a relationship between the entropy of the signal condition (either the preferred walking speed of each subject when there was no stimulus, a metronome, fractional Gaussian white noise, or a Lorenz system of equations that generated entropy values between periodic and random dynamics) and the fractal scaling of the stride interval variability. A quadratic trend with an inverted U shape was found across conditions ordered in increasing entropy. Thus, they concluded that as the entropy of the driving signal increased monotonically from periodic to chaotic to random dynamics, the structure of stride time variability changed from uncorrelated to persistent fractal scaling then back toward uncorrelated (Hunt, et al., 2012). This same research group also examined gait variability and therapy for aging populations by having both young and elderly subjects walk on a treadmill while listening to white noise, a chaotic rhythm, a metronome, and no auditory stimulus. The researchers calculated stride length, step width, and stride intervals for all conditions then used detrended Fluctuation Analysis to find that an inverted U-shape described the relationship between gait variability and the structure of the auditory stimulus for the elderly group, but not for the young group. Thus the gait of the older subjects could be manipulated using auditory stimuli. The main outcomes focused on restoring optimal gait variability through the predictability and complexity of the walking task. This study found an inverted U-shape relationship between the temporal structure of auditory stimulus ordered along the predictability and complexity continuum (Kaipust, et.al, 2013). This proposed project plans to also analyze aspects of a particular music piece and the step movement of subjects. However, the conditions and measurements will differ. Additionally, subjects will not be walking on a treadmill, but will be walking back and forth across a room, with the music playing on speakers instead of headphones.

During the fall of 2015, a pilot study was conducted as a course project, testing if the external cues of music and metronome affect movement patterns and mood (i.e. stress and anxiety). The kinematic data and anxiety measurements of three non-dancers/non-musicians were successfully obtained at UT Austin. We are now ready to propose a full research project with a larger subject pool and more specific objectives based on the pilot study protocol results and pilot subject feedback. This project will examine whether a RAS protocol incorporating music and movement therapy techniques has a significantly different effect on a specified movement pattern and on anxiety, compared to the same movement protocol performed without music. Hypothesis for this project include the following:

1: Compared to the silent condition, it is expected that STAI score differences between before and after completing the movement task done with music will be larger, indicating a larger reduction in anxiety when music was played.

2: Compared to the silent condition, it is expected that, pulse rate and oxygen saturation levels will be lower for the music condition, indicating a larger reduction in anxiety when music was played.

3: For the music condition, there will be a synchronization of movement to the beat and more regular timing in movement pattern than in the silent condition.

4: Comparing the results for each subject for both conditions, there will be a positive correlation between the change in anxiety and change in kinematic movement pattern variables.

4. Procedures

We will collect data from 5 men and 5 women who are non-musicians and non-dancers, between the ages 18-30 years, healthy, and without a history of neurological disorders. All testing will take place in the Developmental Motor Control Lab, BEL 546B. Each participant will come to the lab for two approximately 90 minute sessions separated by 1-2 days. A VICON motion capture system with body markers will be placed on critical points of the body will be used to record precise kinematic data from movement. Therefore, participants will wear tight athletic clothing and athletic shoes. No fasting or dietary restrictions will be required.

<u>Recruitment Procedure</u>

A flyer (attached) describing the study will be posted around the UT Austin campus. Those interested in participating in the study will be directed to contact The Motor Coordination Lab at motorcoordinationlab@austin.utexas.edu. Participation will be entirely voluntary. Initial follow-up contact will be made by the researcher by email (sample communication script attached) and the prospective participants will be sent a qualification questionnaire (attached) to determine whether they qualify based on the criteria mentioned above. The researcher will then establish a mutually agreeable time for the data collection process with the first 10 qualifying participants (5 men and 5 women). Those who do not qualify (and those who respond after the required number of participants has already been met) will be so informed and all information about these volunteers will be destroyed. Dress code and location/parking information will be sent to the participants once mutually agreeable times for data collection are established.

<u>Laboratory Preparation</u>

Preparation steps to be taken by the experiment prior to the participant's testing session will include placing markers on the floor to establish the four end points between which the participant will complete the movement task, having the VICON motion capture system running, having body markers ready with tape to be attached to subject, and having the project's data collection sheet, a finger pulse oximeter, two forms of the 6 item State-Trait Anxiety Inventory (STAI-6) (attached), and a video camera ready for use.

Laboratory Procedure

See sample Data Collection Sheet below for testing session checklist. Upon arrival at the Developmental Motor Control Lab, participants will be asked to rest for 5 minutes sitting. This is to create a standard of resting state among all participants. During this rest period, the participants will review and, after all their questions are answered, sign the informed consent form. They will be given a copy of the form to keep. Then they will complete the STAI-6. Next, while the subject is still seated, the subject's pulse rate and oxygen saturation will be recorded using the finger pulse oximeter. This process of form completions and measurements will take approximately 10 to 15 minutes.

Data Collection Sheet

Session	Subject
Condition (A-silence, B-music)	
Date	
Time	
Age	
Gender	
Participant ID code	
Consent form signed	
5 min rest	
Body markers	
pre STAI-6	
pre PR (beats/min)	
pre SpO2 (%)	
calibration	
Instruction video twice	
Practice trial 1	
Instruction video	
Practice trial 2	
Trial 1	
Trial 2	
remove body markers	
post PR (beats/min)	
post SpO2 (%)	
post STAI-6	

Notes:

Session	Subject
Condition (A-silence, B-music)	
Date	
Time	
Age	
Gender	
Participant ID code	
Consent form signed	
5 min rest	
Body markers	
pre STAI-6	
pre PR (beats/min)	
pre SpO2 (%)	
calibration	
Instruction video twice	
Practice trial 1	
Instruction video	
Practice trial 2	
Trial 1	
Trial 2	
remove body markers	
post PR (beats/min)	
post SpO2 (%)	
post STAI-6	

Notes:

Placement of reflective markers for the purpose of motion capture:
A total of 14 passive infrared light reflecting markers will be placed on the participant’s body landmarks. Double sided tape, specially designed for attaching these markers to the skin will be used. These markers are small 14mm plastic balls that reflect the infrared light projected from the motion capture cameras. We will place the markers on the following points. Time for marker placement is approximately 5 minutes.

1. Right third finger knuckle
2. Left third finger knuckle
3. On bony prominence on top of right shoulder
4. On bony prominence on top of left shoulder
5. Right hip (trochanter)
6. Left hip (trochanter)
7. Right knee (patella)

8. Left knee (patella)
9. On bony prominence on outside of right ankle
10. On bony prominence on outside of left ankle
11. On back of right foot's heel
12. On back of left foot's heel
13. Right foot (on metatarsal of big toe)
14. Left foot (on metatarsal of big toe)

Baseline static motion capture trial:
The participant will be asked to stand still in a T position, with both arms extended outward to the sides from the shoulder and with the feet approximately 10 inches apart. Trial duration will be 10 s. The purpose of this static trial is to obtain a digitized reference of marker locations once placed on the body. Successful completion of this baseline data capture trial should take less than 5 minutes.

Data Collection:

- Each participant will complete a movement task that consists of walking and a whole body structured movement sequence. During one session, each participant will complete this movement task in silence, without any background noise. During the other session, this same movement task will be performed while a music piece is playing. The order of the two sessions will be assigned to participants in a pseudorandom manner, so that five have each session first.
- An initial instructional period will allow the investigator to teach the subject how to perform the movement task. An instructional video about the movement task will be shown to each participant twice. The instructional video will be of an experimenter completing the movement task in the testing space in silence. The subject will then complete a practice trial of the movement task in the dedicated space in silence. The instructional video will be shown to the subject once more. The subject will then complete another practice trial. This thorough instruction period is to help minimize uncertainty and anxiety about the movement task.
- Any questions from the participant about how to conduct the movement task will be answered throughout and after this initial instructional period.
- With regard to questions about their performance of the movement task, participants will only be told that the project is looking at their kinematic movement patterns when there is and is not music. Participants should focus on doing the proper movements and sequence of steps, but not focus on the speed and size of movements. For the session where music is played, each participant will be instructed to listen to the music while completing the movement task. They will be told that the experiment will examine whether the music has any affect on their movement.
- For both sessions, each participant will complete one practice trial in silence before two recorded trials.
- For both test sessions, before starting the movement task for each trial, the experimenter will verbally lead the participant through a 30 second deep breathing exercise while they stand at the starting point. For the session without music, these 30 seconds will be in

silence. For the session with music, these 30 seconds will be while the music has started playing.

Trial Summary

1. Go over general task and procedures
2. Complete consent form
3. Complete pre-task STAI-6
4. Measure pulse rate and oxygen saturation
5. Have body markers placed
6. Calibrate VICON system
7. Show instructional video twice, perform practice trial, watch instructional video once more, perform second practice trial
8. Complete 2 test trials under predetermined condition (silence or with music)
9. Measure pulse rate and oxygen saturation
10. Remove body markers
11. Complete post-task STAI-6 with added questions for feedback (attached)
12. Take video of subject throughout for analysis

Each participant will spend approximately 90 minutes in Bellmont 546B for each session.

Other Information

a. Location

The data will be collected in the Developmental Motor Control Laboratory, Department of Kinesiology, Bellmont 546B, The University of Texas at Austin using a 10-camera VICON Motion Capture System. Data analysis will be done by the investigators using the VICON Nexus software installed in the same laboratory. All electronic file data will be recorded in files with non- identifying file names. Subsequent analyses will be done using Excel and MATLAB installed on other laboratory and/or personal computers. No identifying information will be contained in the raw data files.

b. Resources

There is no external funding for this research study. All equipment to be used resides in the Department of Kinesiology and Health Education.

c. Study Timeline

It will require approximately two 90 minute sessions to collect data from each participant. It will take about 1 month for data collection. Data analysis will be completed within 1 month following cessation of data collection. All analyses and manuscripts are projected to be completed within 8 months of the beginning of the study.

Methods:

5. Measures

A VICON motion capture system will be used to collect kinematic data at 120 Hz.

From the motion data (x,y,z coordinates of reflective markers), a number of kinematic variables will be calculated. The music will be fed into an A/D input channel of the computer (sample rate = 1200 Hz) to be time-synched to the motion data and for subsequent signal analysis to identify the music beat. The motion data will be exported in .csv (comma separated variable) or .txt (text file), and data from both these file types can be imported into MATLAB.

For analysis, several terms used in the gait analysis will be operationally defined. Stance phase is when the heel strikes (first contacts) the ground but the toes have not yet touched. Swing phase occurs after stance phase, between the toe off and heel strike occurrences. Heel strike is the moment in time where the z component of the heel body marker first makes contact with the ground/the initial height of the heel when standing. During normal walking, the first frame of the swing phase is when the z position for the toe body marker changes from negative to positive, since this represents when the whole foot begins to move forward. Step rate (steps/min), or cadence, is how many times a foot touches the ground multiplied by 2 (to account for both feet). Step length would be the forward distance (toe off to heel strike) for one foot. So, for example, right step length, would be from right toe off to the following right heel strike. Stride length is defined to include the steps for both legs. Stride length would be from the right heel strike until the next right heel strike. Stride interval was the time between two consecutive heel strikes of the same leg.

Using the body markers, the kinematic data from the toe, ankle, heel, and hand of both sides will be analyzed. The average inter step time will be found for both conditions by looking at the heel strike and toe-off. The movement from the two conditions will be compared by looking at the variability of this time throughout the trials. The entire movement task (walking and movement sequence) will be treated as a single movement, but could be broken up if a certain section differs in synchronization. Slight fluctuations in the kinematic data are expected to be found due to adjustment from slight balance issues. Based on the results from the pilot data, plateaus in the kinematic data from holding a body part position still are expected to be found. The length of these plateaus will be analyzed to see if there is a time scale factor that is associated with an aspect of the music (e.g. time between beats). For the finger movement data in particular, the movement along the z axis will be analyzed. For the movement done under the music condition, the music sound file with its pronounced beat will be superimposed to see if the stop and start of each body part's movement synchronized with the music (either occurring prior to the beat in anticipatory fashion or after the beat in a delayed fashion).

6. Participants

a. Target Population

Ten subjects (5 men and 5 women) who are between the ages 18-30 years.

b. Inclusion/Exclusion

We will collect data from 5 men and 5 women who are non-musicians and non-dancers, between the ages 18-30 years, healthy, and without a history of neurological disorders.

c. Benefits
This project will examine whether a RAS protocol incorporating music and movement therapy techniques has a significantly different effect on a specified movement pattern and on anxiety, compared to the same movement protocol performed without music. The results of this study have the possibility of expanding research knowledge about the effects of music on movement sequences and anxiety.

d. Risks
The risks associated with this study are minimal, no greater than in everyday life. One potential risk is fatigue from completing the movement task. However, this risk is small due to the short duration and low intensity of the movement task. Another potential risk is anxiety about the performance on the movement task. Subjects will have an instructional period prior to the movement task so that they can become familiar with it and they may ask questions about it at any time, which should mean they should have less anxiety about performing the task. They should remember that their performance will not be judged by any performance standard nor result in any negative consequence for them, and that they may choose to stop participating at any time.

e. Recruitment
A flyer (attached) describing the study will be posted around the UT Austin campus. Those interested in participating in the study will be directed to contact The Motor Coordination Lab at motorcoordinationlab@austin.utexas.edu. Participation will be entirely voluntary. Initial follow-up contact will be made by the researcher by email (sample communication script attached) and the prospective participants will be sent a qualification questionnaire (attached) to determine whether they qualify based on the criteria mentioned above. The researcher will then establish a mutually agreeable time for the data collection process with the first 10 qualifying participants (5 men and 5 women). Those who do not qualify (and those who respond after the required number of participants has already been met) will be so informed and all information about these volunteers will be destroyed. Dress code and location/parking information will be sent to the participants once mutually agreeable times for data collection are established.

f. Obtaining Informed Consent
When the participant comes in for participation, the participant will be given a copy of the consent form. He/she will be asked to review the

consent letter. Then the investigator will ask if the participant has any questions. Once all questions have been answered, the participant will be asked to sign the consent letter. Upon signing, the participant will be reminded that participation is voluntary and that he/she can cease participation at any time and for any reason. All data collected up to the point of withdrawal will not be included in subsequent analyses. Each participant will be given a copy of the consent form to keep.

7. Privacy and Confidentiality
Each participant's privacy will be ensured through the use of a private laboratory setting. The investigator and laboratory assistants present during data collection will be the only individuals present for data collection.
   a. Subject ID
   Once a participant is found to be qualified for the study and their testing sessions are scheduled, they will be assigned a subject ID code which will be used in place of their name to identify them.
   This code will have the format of YEAR.MONTH.DAY.GENDER.SUBJECT NUMBER.SESSION. Year, month, and day are represented by two places. For gender, the letter M will represent males and the letter F will represent females. For subject number, two number places will be given to assign subject numbers 01-10 (or more if additional subjects are needed to be collected due to testing error). For session, the letter A will be assigned for when the movement task is done is silence and the letter B will be assigned for when the movement task is done with music. So, for example, a female subject who is the sixth subject to be tested, is being tested in the silent condition, and the testing session is occurring on 4/26/16, will have a subject ID of 16.04.26.F.06.A.
   This subject ID will be used in this exact form for those selected to participate, STAI surveys, and for any notes or interviews on the subject. Any alterations to this ID for other aspects of the study are described below:
      ii. VICON Video capture of movement
      For calibration trial: Subject ID with 'calib' after
      Example: 16.04.26.F.06.Acalib
      For test trials: Subject ID with two places for the trial number after
      Example: 16.04.26.F.06.A01 for test trial 1.
      (i) Oximeter data.
      The pulse rate and oxygen saturation data obtained from the oximeter for each subject will be recorded in each subject's individual data collection sheet which will be identified by their subject ID.

8. Compensation
There is no compensation for participation in this study.

9. References

Hunt, Nathaniel, Joshua L. Haworth, Denise McGrath, Sara Myers, and Nicholas Stergiou. "Manipulation of the Structure of Gait Variability with Rhythmic Auditory Stimulus." *American Society of Biomechanics* (2012): n. pag. Web. 1 Dec. 2015.

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Marteau, T. M., & Bekker, H. (1992). The development of a six-item short-form of the state scale of the Spielberger State-Trait Anxiety Inventory (STAI). Retrieved February, 2016, from http://onlinelibrary.wiley.com/doi/10.1111/j.2044-8260.1992.tb00997.x/pdf

Nombela, C., Hughes, L. E., Owen, A. M., & Grahn, J. A. (2013, December). Into the groove: Can rhythm influence Parkinson's disease? Retrieved November, 2015, from http://www.sciencedirect.com/science/article/pii/S0149763413001930

Sample Email to be sent to Recruitment Respondents

Hello-

Thank you for your interest in participating in the Movement and Music Affect study. Below is a screening questionnaire to see if you qualify for participation. Please complete all questions.

Please answer yes if you have consumed any of these drugs over the past 24 hours.
NOTICE: These are disqualifying conditions.
Answer (Yes/No)
_____ 1. CNS Depressants (Alcohol, Valium, Librium, Xanax, Prozac, and Thorazine,GHB (Gamma Hydroxybutyrate), Rohypnol and any other anti-depressants (etc. Zoloft, Paxil)
_____ 2. CNS Stimulants (Cocaine, Amphetamines, Methamphetamines)
_____ 3. Hallucinogens (LSD, Peyote, Psilocybin, Ecstasy)
_____ 4. Phencyclidine (PCP) and Analogs
_____ 5. Narcotic Analgesics (etc. Opium, Codeine, Heroin, Demerol, Darvon, Morphine, Methadone, Vicodin and OxyContin)
_____ 6. Inhalants
_____ 7. Marijuana
_____ 8. Allergy medications (etc. Benadryl)

Please answer yes if you have experienced any serious injury or medical as described below. If you answer yes, you will be disqualified from participation in this study.

_____ 9. Any previous medical diagnosis and treatment of neurological disability,musculoskeletal injury, or neurological complications in your body.
_____ 10. Vision problems impairing your ability to complete a movement task involving spotting locations on the floor in a room.

Please answer yes if the following statement applies to you. If you answer yes, you will be disqualified from participation in this study.

____ 11. Previous organized experience with music and dance (e.g. school dance team, school band, several years of playing an instrument).

If you did not answer yes to any of the above answers, then you qualify for this study. If you are interested in participating, please reply to this email that you meet all screening qualifications, understand that it is a volunteer (no payment) participation study, and that you are available to participate for two 90 minutes testing sessions within 1-2 days of each other.

Pre-STAI

Date:
Session:
Subject:

State-Trait Anxiety Inventory (STAI)
Self-evaluation questionnaire (Y-6 item)

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the most appropriate number to the right of the statement to indicate how you feel ***right now, at this moment.***
There are no right or wrong answers. Do not spend too much time on any one statement, but give the answer which seems to describe your present feelings best.

	Not at all	Somewhat	Moderately	Very much
1. I feel calm	1	2	3	4
2. I am tense	1	2	3	4
3. I feel upset	1	2	3	4
4. I am relaxed	1	2	3	4
5. I feel content	1	2	3	4
6. I am worried	1	2	3	4

Please make sure that you have answered *all* the questions.

Post-STAI

Date:
Session:
Subject:

State-Trait Anxiety Inventory (STAI)
Self-evaluation questionnaire (Y-6 item)

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the most appropriate number to the right of the statement to indicate how you feel ***right now, at this moment.***
There are no right or wrong answers. Do not spend too much time on any one statement, but give the answer which seems to describe your present feelings best.

	Not at all	Somewhat	Moderately	Very much
1. I feel calm	1	2	3	4
2. I am tense	1	2	3	4
3. I feel upset	1	2	3	4
4. I am relaxed	1	2	3	4
5. I feel content	1	2	3	4
6. I am worried	1	2	3	4

Please make sure that you have answered *all* the questions.

Post-STAI Interview Questions

Date:
Session: Silence
Subject:

During the walking portion of the movement task, what were you mainly focusing on?

During the movement sequence portion, what were you mainly focusing on?

Was the movement sequence portion difficult to learn and remember?

Post-STAI Interview Questions

Date:
Session: Music
Subject:

During the walking portion of the movement task, what were you mainly focusing on?

During the movement sequence portion, what were you mainly focusing on?

How were you focusing or paying attention to the music?

Was the movement sequence portion difficult to learn and remember?

Did you recognize the music being played?

What genre of music do you prefer to listen to on your own? You can list several types if more than one.

Is exercise and/or physical activity part of your regular schedule? If yes, how often do you listen to music when partaking in these activities?

Do you listen to music while doing other activities (e.g. reading, studying, driving)? If so what kind and which activities?

Volunteers Needed

Movement and Music Affect study is seeking participants

Must be

- Between the ages of 18 and 30
- Have no history of neurological disorders
- Have no formal dance or music background
- Able to perform normal activities of daily living

This research study will examine the effects that music has on movement patterns and mental state. All participants will be asked to come in for two testing sessions, each approximately 90 minutes, and complete the following for each session:

- Learn and perform a novel movement task while wearing reflective body markers so that your movement can be recorded by a motion capture system. In one of the two sessions, music will be playing during this task.
- Before and after the movement task, your mental state will be assessed by a questionnaire and physiological measures (pulse rate and oxygen saturation).

This study will be conducted in Bellmont Hall 546B, The University of Texas at Austin.

If interested, please contact The Motor Coordination Lab at motorcoordinationlab@austin.utexas.edu.

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Consent for Participation in Research

Title: Rhythm and Blues: The effect of music on movement patterns and anxiety

Introduction

You are being asked to participate in a research study. This form provides you with information about the study. A person conducting this research study will also describe this study to you and answer any questions you may have. Please read the information below and ask questions about anything you don't understand before signing to indicate your consent. Your participation is entirely voluntary and you can refuse to participate or stop this study at any time without penalty or loss of benefits to which you are otherwise entitled. If you decide to be involved in this study, this form will be used to record your consent.

Purpose of the Study

The purpose of this study is to determine both the effect that music has on movement patterns and anxiety as well as the relationship between movement patterns and anxiety when these two factors are affected. This will require you to complete an anxiety questionnaire and physiological measurements before and after performing a movement task in each of two sessions separated by 1-2 days.

Qualification Requirements of the Study

To be eligible to participate, you must meet the following requirements:

- Be between the ages of 18 and 30
- Not have consumed any of these drugs over the past 24 hours:
    - CNS Depressants (Alcohol, Valium, Librium, Xanax, Prozac, and Thorazine,GHB
    - (Gamma Hydroxybutyrate), Rohypnol and any other anti-depressants (etc. Zoloft, Paxil)
    - CNS Stimulants (Cocaine, Amphetamines, Methamphetamines)
    - Hallucinogens (LSD, Peyote, Psilocybin, Ecstasy)
    - Phencyclidine (PCP) and Analogs
    - Narcotic Analgesics (etc. Opium, Codeine, Heroin, Demerol, Darvon, Morphine, Methadone, Vicodin and OxyContin)
    - Inhalants
    - Marijuana
    - Allergy medications (e.g. Benadryl)
- Not have any previous medical diagnosis and treatment of neurological disability, musculoskeletal injury, or neurological complications in your body.
- Not have vision problems impairing your ability to complete a movement task involving spotting locations on the floor in a room.
- Not have previous formal experience/background with music and dance (e.g. school dance team, school band, several years of playing an instrument).

What will you be asked to do?

If you agree to participate in this study, you will be asked to do each of the following on each of the two days of testing for this study:

- You will complete a movement task while wearing reflective body markers so that the movement can be recorded by a VICON motion capture system (music will be played during one session of this experiment). You will perform 2 test trials, and video will be taken while you are performing.
- You will first have an instruction period where you will be shown an instructional video of the movement task as well as completing 2 practice trials
- Complete a 6 item State-Trait Anxiety Inventory (STAI) questionnaire that assesses anxiety before and after performing the movement task
- Have pulse rate and blood oxygen saturation level taken using a non-invasive pulse oximeter before and after the movement task

You will be tested in two sessions, separated by 1-2 days. The total estimated time of participation in this study will be about 90 minutes for each session, depending upon the amount of time to complete initial state readings and the questionnaire, the instructional period, calibration of the VICON system, actual test trials, and to complete the paper work. The study will include approximately 10 volunteer participants.

What are the risks involved in this study?

- The risks associated with this study are minimal, no greater than in everyday life.
- One potential risk is fatigue from completing the movement task. However, this risk is small due to the short duration and low intensity of the movement task.
- Another potential risk is anxiety about your performance on the movement task. You will have an instructional period prior to the movement task so that you can become familiar with it and you may ask questions about it at any time, which should mean you should have less anxiety about performing the task. You should remember that your performance will not be judged by any performance standard nor result in any negative consequence for you, and that you may choose to stop participating at any time.

What are the potential benefits of this study?
There are no direct benefits to you of participating in this study, though it is that possible you will enjoy learning about the operations of a VICON motion capture system. The results of this study have the possibility of expanding research knowledge about the effects of music on movement sequences and anxiety.

Do you have to participate?
No, your participation is voluntary. You may decide not to participate at all, or if you start the study, you may withdraw at any time. Withdrawal or refusing to participate will not affect your relationship with the University of Texas at Austin in any way.

If you would like to participate, you should sign this form, after reading all of it. You will then also receive a copy of this form to keep.

Will there be any compensation?
No, you will not receive any type of payment for participation in this study.

How will your privacy and confidentiality be protected if you participate in this research study?
Your privacy and the confidentiality of your data will be protected by making sure that all data will contain no identifying information that could associate you with it, or with your participation in any study. Group scores will primarily be analyzed and described publicly, and if any individual scores are used as examples of the data collected they will only be displayed using the identification code that each participant is assigned when they sign this consent form. Each participant's code and name will be kept together on only one hard copy document, which will be kept inside the locked laboratory in BEL 848 and will be available only to researchers associated with this research project.

If it becomes necessary for the University of Texas Institutional Review Board to review the study records, information that can be linked to you will be protected to the extent permitted by law. Your research records will not be released without your consent unless required by law or a court order. The data resulting from your participation may be made available to other researchers in the future for research purposes not detailed within this consent form. In these cases, the data will contain no identifying information that could associate it with you, or with your participation in any study.

Whom to contact with questions about the study?
Prior to, during or after your participation you can contact the principal investigator, Michelle Dunn, at 832-444-5631, or send an email to medunn@utexas.edu for any questions or if you feel you have been harmed. You may also contact the faculty sponsor, Lawrence Abraham, at 512-475-7000 or l.abraham@austin.utexas.edu. This study has been reviewed and approved by The University Institutional Review Board and the study number is xxxx-xx-xxxx.

Whom to contact with questions concerning your rights as a research participant?
For questions about your rights or any dissatisfaction with any part of this study, you should contact, anonymously if you wish, the Institutional Review Board by phone at (512) 471-8871 or email at orsc@uts.cc.utexas.edu.

Participation
If you agree to participate please sign and date below, then return this form to the investigator. You will receive a copy of this form to keep.

Signature
You have been informed about this study's purpose, procedures, qualification requirements, possible benefits and risks, and you have received a copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time. You voluntarily agree to participate in this study. By signing this form, you are not waiving any of your legal rights and are agreeing to meet the qualifications for participation in this study.

____
Printed Name

____ _______________
Signature Date

As a representative of this study, I have explained the purpose, procedure, benefits, and the risks involved in this research study.

____
Printed Name of Person obtaining consent

____ _______________
Signature of Person obtaining consent Date